New Scientist

WEEKLY 6 January 2024

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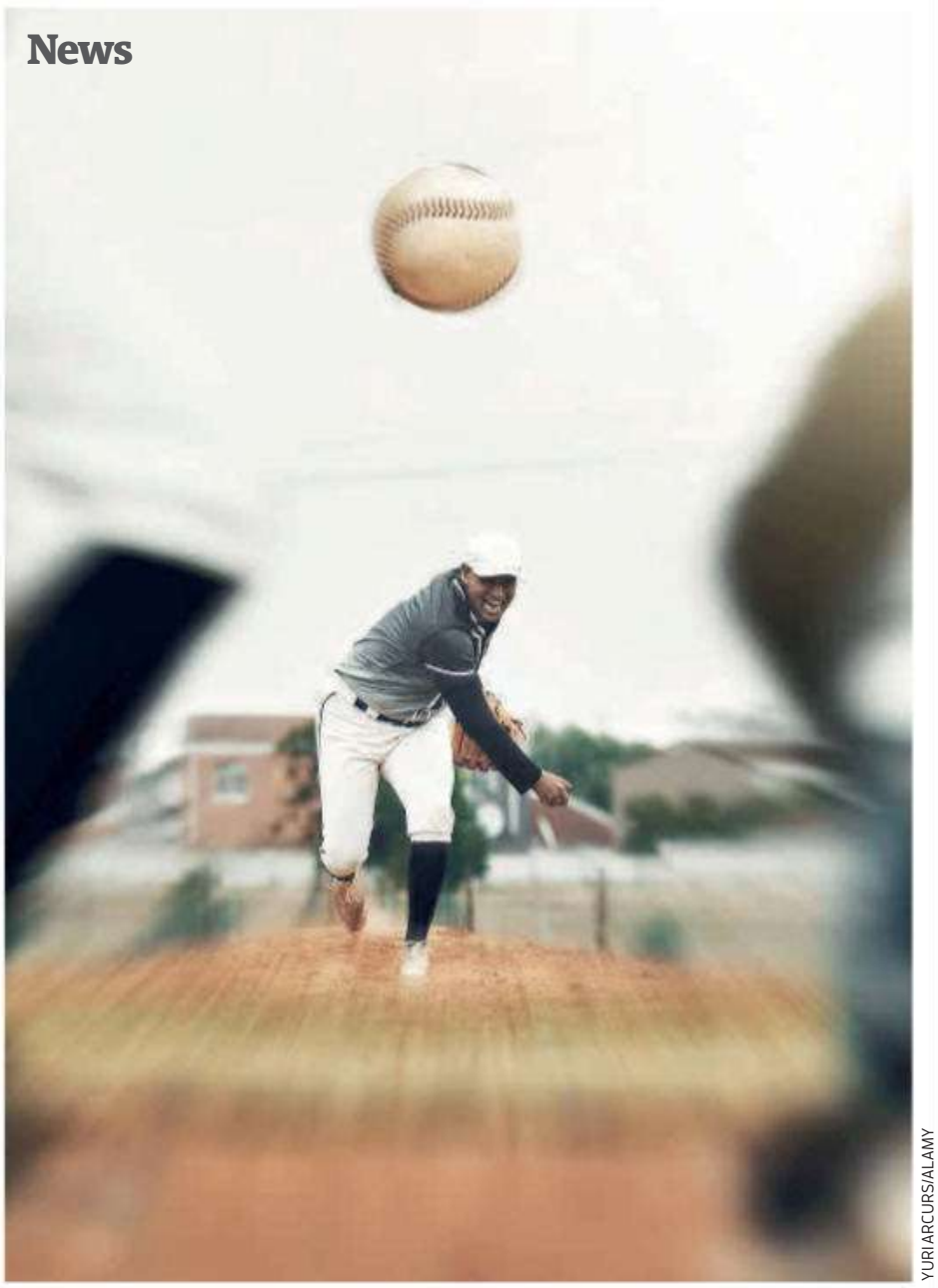

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Event

Instant Expert: Brain

Join six leading brain scientists on 10 February as they reveal, by way of the latest research in neuroscience, psychology and physiology, what is going on in our heads when we think, feel and communicate. Gain insights into how to boost your cognitive performance and live a healthier, happier life. For 2024, we have cut ticket prices and introduced a new "super early bird" option for our Instant Expert events, held at London's Conway Hall.

newscientist.com/events

Tour

Whale watching in the Azores: Portugal

Search for blue whales, sperm whales and several dolphin species in an archipelago packed with flora and fauna, volcanic craters, lagoons and picturesque towns. Take part in marine research and learn firsthand from oceanographer Russell Arnott. This seven-day trip starts on 7 May 2024 and costs £3399.

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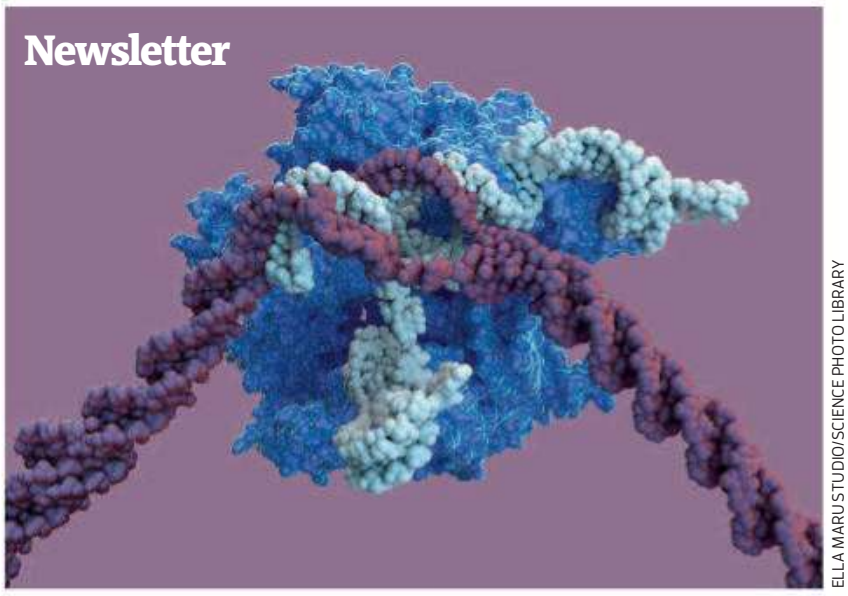
Podcast

Escape Pod

Revisit *New Scientist*'s Escape Pod series, which begins by discussing the self-awareness of dolphins and whales and the intricacies of their language and vocalisations. The panel also marvels at the seemingly impossible abilities of gymnasts. Plus, hear about the Chinese board game Go, which has more possible moves than there are atoms in the universe.

newscientist.com/nspod



ELLA MARU STUDIO/SCIENCE PHOTO LIBRARY

Gene editing A first-of-its-kind CRISPR therapy treats anaemia

SHUTTERSTOCK/DALIU

Explore the Azores Uncover wildlife and riveting volcanic geology

Video

Pollution hunters

Soraya Wooller volunteers for UK campaign group Windrush Against Sewage Pollution by testing treated wastewater that is discharged into the river Windrush. Over the past decade, this waterway has turned opaque, algae have bloomed and fish populations have diminished. Wooller reckons a local sewage works is to blame and encourages others to join her.

youtube.com/newscientist

Newsletter

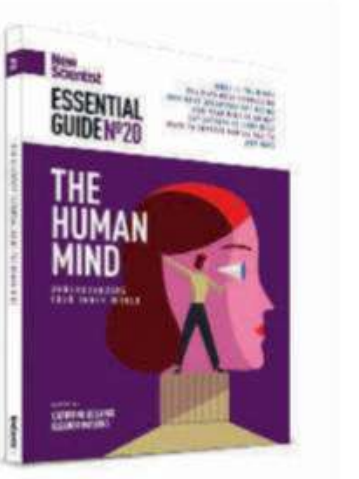
Health Check

Health reporter Clare Wilson looks back at five big health stories from 2023 that also gave us something to be cheerful about. For example, we passed a milestone for gene therapies with the approval of the first treatment that uses CRISPR gene-editing technology, 13 years after its discovery.

newscientist.com/health-check

Video

"It seems to me that nature's police are looking the other way"



Essential guide

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A harmful divide

Ending medical science's enduring neglect of women's health must be accelerated

ENDOMETRIOSIS, menopause, menstrual pain, pelvic floor weakness, premature egg failure, miscarriage... the list of poorly studied "women's problems" goes on. Now let's add another: postnatal anxiety.

Of course, when you are caring for a newborn child, it is normal to feel anxious. But as we discover in our feature on page 40, for one in five mothers, this can develop into acute, long-term anxiety, which can lead to depression, insomnia and physical illness. Despite this, researchers are only just beginning to realise the extent of its prevalence and investigate potential causes and possible treatments. Unfortunately, this early research hasn't yet trickled down into the real world, with many doctors still unaware of the condition.

This is yet another example of the vast gaps in our knowledge of women's health. It isn't a new problem. Half the population has been underserved in medicine for a long time – recall the menopause trial in the 1960s that included 8341 men and no women, for instance. Or the Baltimore Longitudinal Study of Aging, which featured only men in its first two decades.

"Recall the research into menopause that included 8341 men and no women"

We have moved on from such absurdities, of course, yet it was only in 2016 that the US National Institutes of Health mandated that studies it funds must include female animals. And recent statistics suggest that still only 2 per cent of medical research funding globally is spent on pregnancy, childbirth and female reproductive conditions, despite one in three women reporting a gynaecological or reproductive health problem in their lifetime.

Thankfully, we are moving in the right direction. Last year, the Women's Health Strategy for England was launched. This 10-year project aims to improve health experiences and outcomes for women. In November, US president Joe Biden announced the first ever White House initiative on women's health research, an effort aiming to pioneer new discoveries in this sphere. More such programmes are needed. Sidelining of women's health is a problem – let's make solving it a priority.

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CONTACT US
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General & media enquiries
UK **Tel**+44 (0)203 615 6500
9 Derry Street, London, W8 5HY
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US 600 Fifth Avenue 7th Floor | NY 10020 | USA

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Accelerated ageing
Girls' brains aged faster in covid-19 lockdowns p15

Earth

Japan's earthquake devastation

Smoke rises from the wreckage of collapsed homes in Wajima, Japan, as fires burn after a spate of earthquakes. The biggest, a magnitude-7.6 quake, hit the areas around Toyama and Niigata on 1 January. The number of people confirmed dead was close to 50 as *New Scientist* went to press, with rescuers still searching for people trapped beneath the rubble.

THE ASAHI SHIMBUN VIA GETTY IMAGES

Biotechnology

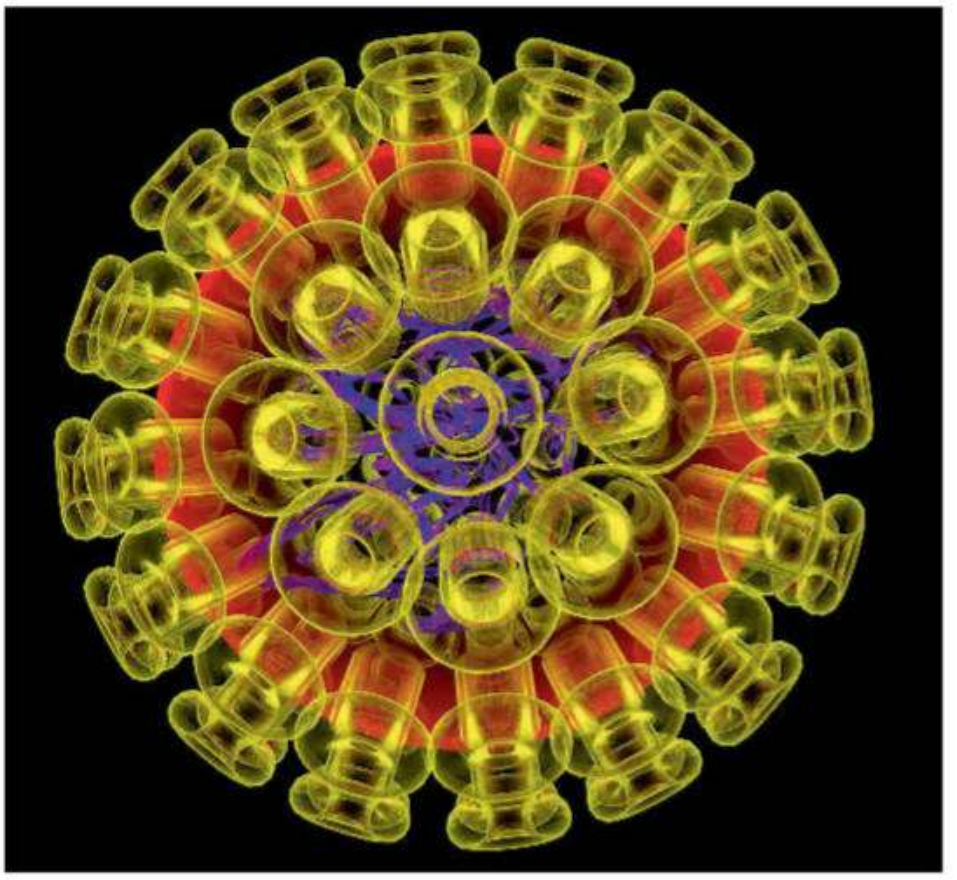
Set a virus to catch a virus

A virus engineered using CRISPR technology spread its DNA to other viruses in a mouse study, which could be used to make pathogens harmless, finds **Michael Le Page**

A VIRUS genetically engineered to spread its DNA to other viruses via CRISPR gene editing has done exactly that in tests in mice. The hope is that these viruses could alter others, such as herpes, in a way that prevents them from causing symptoms.

"It's a new technology," says Marius Walter at the Fred Hutch Cancer Center in Seattle, Washington. "Can we bring it to people? That's a long way ahead, we have a lot of work to do, but I think this is an exciting technology."

This approach is known as a gene drive, when a bit of DNA somehow manages to get passed down to a higher proportion of offspring than normal. This means gene drives can spread through a population even if they are disadvantageous.



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An illustration of a herpes simplex type 1 virus, which was used in a gene drive

In the past century, scientists have discovered many natural gene drives that work via a wide variety of mechanisms. Then, in 2014, Kevin Esvelt at the Massachusetts Institute of Technology and his colleagues outlined how CRISPR gene editing could be used to create powerful artificial gene drives. By 2018, CRISPR gene drives were working in caged mosquitoes, with the aim of stopping the spread of malaria.

In animals that reproduce sexually, CRISPR gene drives work by copying and pasting themselves from one chromosome to another, meaning they end up in all eggs or all sperm – and therefore all offspring – instead of half, as would usually be the case.

A virus doesn't reproduce sexually. Instead, it replicates by getting the cell it infects to make lots of copies of it, so the assumption was that gene drives couldn't work in viruses.

But cells are sometimes infected by more than one type of virus at a time, and Walter realised that such co-infections provide an opportunity for gene drives to work.

If a gene drive-carrying virus infects a cell at the same time as a normal virus, the gene drive can copy and paste itself into the DNA of all the new viruses being made. If further co-infections keep happening, eventually all the viruses causing an infection inside an individual will carry the gene drive.

"The issue of unwanted transmission to other individuals would need careful investigation"

"I got this idea of, 'Oh, let's try to make a gene drive'," says Walter. "At that point, it was a bit of a crazy idea, but we ended up making it work."

In 2020, his team reported that a viral gene drive can work in human cells growing in a dish. When cytomegaloviruses with and without a gene drive were introduced, the gene drive spread until it was carried by more than 95 per cent of the viruses.

The reaction of most biologists to the paper was that viral gene drives wouldn't work during a real infection because they thought co-infections were much rarer in bodies than in cells in a dish.

To prove the sceptics wrong, Walter's team infected mice with herpes simplex type 1 viruses in which 15 per cent of the viruses carried a gene drive. After four days, the proportion of viruses with the gene drive had risen to between 60 and 90 per cent (bioRxiv, doi.org/gs8cf9).

This shows that viral gene drives can work in animals. However, there are limitations. For instance, the approach will work only with DNA viruses, not RNA ones – such as flu and the SARS-CoV-2 virus that causes covid-19 – because, among other things, RNA viruses are typically too small to carry a gene drive.

The approach will also probably be most useful for treating persistent infections – for instance, in people with weakened immune systems – or latent infections, where viruses lie dormant in cells and occasionally reactivate, as happens with herpes.

With infections that last only a week or two, using a gene drive probably wouldn't help much by the time someone was diagnosed.

If, however, a gene drive were allowed to spread from individual to individual, this could make all the viruses circulating in a population less dangerous, but Walter neither aims to do this nor thinks it would ever be allowed.

He is now testing ways of using viral gene drives to stop dormant herpes viruses from reactivating and causing symptoms. But regulators may be reluctant to approve treatments designed to spread DNA, even to treat individuals. Existing live vaccines sometimes pass pathogens to non-vaccinated people and the risks would be greater with gene drive-carrying viruses.

"The issue of unwanted transmission to other individuals would need careful investigation," says Esvelt. This would be hardest to prevent with viruses that can cause latent infections, he says. "As far as current medical ethics is concerned, that would be a non-starter."

Yet even if viral gene drives are never used to treat people, they could still teach us a lot, says Walter. "The fact that we're seeing such a high level of co-infection tells us about the way the [herpes] virus spreads naturally," he says. "We're developing the technology, but also discovering some interesting biology." ▮

Zoology

Monkeys in Thailand took up stone tools when covid-19 stopped tourism

Michael Marshall

WILD monkeys began using stone tools for the first time on a Thai island amid the coronavirus pandemic, when travel restrictions meant they were no longer being fed by tourists.

Several groups of primates use stone tools, but we haven't been able to study the origins of this behaviour before, says Jonathan Reeves at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. "We can observe it and we get to see it, but seldom do we get the chance to see it emerge as a new behaviour."

The monkeys in question are common long-tailed macaques (*Macaca fascicularis fascicularis*). Hundreds of them live on Koh Ped, a small island close to the city of Pattaya. Tourists visiting the city often take a boat to the island and feed the monkeys mangoes, cucumbers and nuts.

Researchers led by Suchinda Malaivijitnond at Chulalongkorn University in Bangkok, Thailand, have been visiting the Koh Ped macaques for a decade. They never saw them use stone tools before 2020. Then came the covid-19 pandemic. Tourists didn't visit because of travel restrictions and nor could the researchers. When they finally returned in July 2022, they saw two adult male monkeys using pebbles to break open oyster shells.

On a follow-up visit in March 2023, the team systematically looked for tool-use and saw 17 monkeys using stones to crack open oysters. They did so in a clumsy way: the monkey would lift a rock in both hands to about shoulder height, then throw it at the oyster bed (*American Journal of Primatology*, doi.org/k9hn).

Some long-tailed macaques acquired new skills during lockdown

CHRISTOPHE COURTEAU/NATURE PICTURE LIBRARY/ALAMY

"When we think about the broader diversity of primates, stone tool use is really rare," says Reeves, who wasn't involved in the study. Previously, five populations were known to use stone tools: chimpanzees, bearded capuchins, yellow-breasted capuchins, white-faced capuchins and Burmese long-tailed macaques (*M. fascicularis aurea*), which are closely related to the Koh Ped macaques.

In fact, a 2018 experiment on captive *M. fascicularis fascicularis* found that they failed to learn to use stone tools, despite being given training. The implication was that they didn't have the capacity to do so. However, the new data on wild macaques suggests the issue was incentive, says Reeves: the animals had experienced two years of food shortages, giving them a strong motivation to innovate.

The researchers say the monkeys they saw using stone tools were typically foraging alone. Reeves says it would be good to follow up and see when different individuals start using tools and who they associate with, to see if social learning is involved or if it is about individual creativity.

However, tourists are again visiting Koh Ped and feeding the macaques. Malaivijitnold's team says this might cause the monkeys to stop using stone tools, dashing further studies of this behaviour. ▮

Astronomy

Radio bursts from space exhibit 'sad trombone' effect

SHORT, powerful bursts of radio waves from space are getting stranger and stranger. Astronomers have spotted 35 of these bursts from a single object with a pattern unlike any we have seen before.

Sofia Sheikh at the SETI Institute in California and her colleagues observed this object, a fast radio burst (FRB) called FRB 20220912A, for 541 hours using the Allen Telescope Array in California. In each of the bursts from this FRB, they saw a phenomenon called the "sad trombone" effect, where the frequency of the radio waves drops over the course of the burst.

The sad trombone effect has been seen before, but the bursts from FRB 20220912A also displayed a new pattern. Over time, the frequency and bandwidth of the bursts dropped with respect to the ones before (arXiv, doi.org/k9hp).

"The sad trombone effect is a burst-by-burst effect – you can see it if you look at a single burst. But then in these sets of bursts, the frequency also appears to be decreasing," says team member Wael Farah, also at the SETI Institute. "It's like a long, sad trombone effect – a trombone that is being saddened over a really long period of time."

It isn't clear what could explain this elongated drop-off, especially because the cause of FRBs remains unknown. One leading idea is that these bursts come from magnetars, which are spinning, highly magnetised neutron stars. But no model has been able to account for all the behaviours of all the FRBs that have been observed.

"It's like a trombone that is being saddened over a really long period of time"

"My understanding is that no one has really checked if the current magnetar models could explain the frequency decrease that we see, because it had never been observed before," says Sheikh. "This FRB's behaviour is still relatively consistent with magnetars – the question is which sub-class of magnetar models will be able to explain this behaviour." ▮

Leah Crane

Mental health

Home-use headset eases depression

Brain-zapping device relieves symptoms as well as antidepressants do

Clare Wilson

USING a headset at home to deliver a low electrical current to the brain can relieve symptoms of depression. The approach, called transcranial direct current stimulation (tDCS), is effective when used several times a week for half an hour at a time.

Previous trials have shown that the therapy works under medical supervision in a clinic or lab. Now, a randomised trial has demonstrated that a tDCS headset can also reduce depression symptoms when worn at home.

Depression is usually treated with talking therapies or by taking antidepressant medicines, but these don't help everyone.

Several forms of electrical brain stimulation may have the potential to treat depression. With tDCS, sponge electrodes are placed on the left and right sides of the forehead, causing a mild current to flow from the left to the right.

FLOW

The Flow depression headset uses electrical current to stimulate parts of the brain

This makes brain cells on the left side more likely to fire, with some studies suggesting that activity in this region, known as the left dorsolateral prefrontal cortex, is low in people with depression.

Repeated sessions of stimulation may lead to longer-term changes in the brain cells, increasing their activity levels, says team member Cynthia Fu at the University of East London. Affecting activity in this region probably changes activity in multiple areas, she says. "There are probably many brain regions underlying depression."

To see if people can benefit from using such a device at home, Fu and her colleagues tested a tDCS headset made by Swedish firm Flow Neuroscience. The firm sponsored the study, but "had no role in data analysis, interpretation of data, decision to publish, or manuscript preparation", the researchers write in their paper.

The team randomly assigned 174 people with moderate or severe depression to receive either a full session of stimulation from the Flow headset or stimulation from the same device that lasted just a few seconds, so people felt their skin tingling, at the start and end of each session.

They were shown how to use the headset at home alone for 10 weeks via an online video call.

While the depression symptoms of both groups improved on a 52-point scale, those who got the real treatment showed the most benefit, by about 9 points compared with 7, a degree of difference that is similar to that seen with antidepressants (medRxiv, doi.org/k9hq). "We found people liked having it at home," says Fu. "Participants could build it into their day."

"The results may get these depression-treating headsets taken more seriously by doctors"

Those who got the real stimulation were more likely to report skin redness and irritation, however, and two people experienced burns from using sponges that had dried out.

The results may get such headsets taken more seriously by doctors, says Nick Davis at Manchester Metropolitan University, UK. "This feels really positive," he says. ▮

Food science

Microbes identified that give cheddar its distinct flavour

THE nutty, creamy flavour of cheddar cheese varies according to a delicate balance of bacteria, which has now been identified. Understanding these bacterial interactions could help cheese-makers achieve specific flavours.

All fermented food and drinks – including cheese, kimchi and kombucha – rely on interactions between microorganisms. To make cheese, starter cultures are added to milk to kick-start fermentation and acidify the product, leading to a slightly tangy taste.

Cheese-makers have long understood that some of the key bacteria involved in this process are *Streptococcus thermophilus* and types of *Lactococcus*, but little was known about how these interact and if those interactions influence a cheese's flavour.

Chrats Melkonian at Utrecht University in the Netherlands and his team have now made cheddar cheese using four starter cultures. One came from industrial producers and contained *S. thermophilus* and types of *Lactococcus*, mainly *L. lactis* and its subspecies *L. cremoris*. The others were made by the researchers and contained either the same bacteria as before, no *S. thermophilus* or no *Lactococcus*.

One year later, the team found the cheese made from the starter without *S. thermophilus* had much lower populations of types of *Lactococcus* than the others, even the cheese made using the starter without any *Lactococcus* types to start off with. This suggests *S. thermophilus* is important in enhancing *Lactococcus* growth, says Melkonian.

JULIAN EALES/ALAMY

Cheddar cheese is often creamy and nutty, but can also have fruity or meaty notes

When it comes to flavour, *L. cremoris* seems to regulate the development of the chemicals diacetyl and acetoin, which provide a buttery flavour, but can lead to an "off" taste in high volumes.

***L. cremoris* also increased the concentration of compounds that add subtle meaty and fruity notes, say the researchers. In the absence of this subspecies, the cheeses tended to have higher levels of chemicals that add hints of nutty and creamy flavours (*Nature Communications*, doi.org/k9ks).**

The findings could help cheese-makers tweak their products or inform computer simulations that could formulate a starter with certain bacterial proportions for a desired flavour, says Melkonian. ▮

Chen Ly

Space

Dead satellites seed upper atmosphere with bits of metal

Leah Crane

WHEN satellites reach the end of their lives, they fall into Earth's atmosphere and burn up. This is generally considered harmless, but as more satellites are launched and eventually de-orbited it could begin to affect the climate.

Daniel Murphy at the US National Oceanic and Atmospheric Administration's Chemical Sciences Laboratory and his colleagues used the Particle Analysis by Laser Mass Spectrometry (PALMS) instrument to study hundreds of thousands of atmospheric particles above Alaska.

The PALMS instrument sits in a high-altitude aircraft and uses lasers to measure particulate matter. There are two main sources of metals in the stratosphere: meteoroids and satellites. Satellite remains tend to contain aluminium and other elements and compounds that aren't formed naturally on meteoroids.

About half of the particles in the stratosphere have metals in them, and the researchers found that about one-fifth of those particles seem to have come from satellites and other spacecraft. "About 10 per cent of the particles in the stratosphere contain aluminium alloys from spacecraft, and that's an extraordinary number," Murphy told a recent meeting of the American Geophysical Union in California.

While this probably isn't enough to meaningfully affect the stratosphere, there are plans to increase satellite numbers. Ice forming in the atmosphere tends to begin around solid particles in a process called nucleation, leading to clouds, and the way these metals affect other particles in the atmosphere could boost that process. "We don't know anything definite yet… but ice nucleation may be one of the major impacts," said Murphy. Stratospheric clouds can destroy ozone molecules in the polar regions, so seeding more clouds could be a big problem. ▮

Neuroscience

People's 'speed of sight' varies and this may explain sporting prowess

Clare Wilson

YUICHI MASUDA/GETTY IMAGES

Some people see fast-moving objects more clearly, while others miss them

OUR ability to perceive rapid changes in visual scenes over time – our "speed of sight" – varies a surprising amount between people, according to the first study to systematically investigate the question.

This suggests that some people can track fast-moving objects better than others because of their innate superior vision, which may contribute to people's different abilities in sports like baseball and cricket, says Clinton Haarlem at Trinity College Dublin, Ireland.

Our speed of sight is also known as the flicker fusion threshold, because if a light is flashing on and off at a frequency above someone's threshold, it appears to them to be shining steadily.

"It's comparable to how many 'frames per second' our visual system processes," says Haarlem.

This threshold varies widely in the animal kingdom, being higher in creatures that can move faster, especially if they hunt other speedy animals. For instance, the peregrine falcon, the fastest creature on Earth thanks to its plummeting hunting dives, has a flicker fusion frequency of about 130 images per second, or 130 hertz.

The upper threshold for humans is often taken as a flicker rate of about 60 Hz.

To find out how much this ability varies between individuals, Haarlem and his colleagues asked 88 people from the university to view a flickering light, the frequency of which could be adjusted.

50

Maximum "frames per second" our eyes detect on average

They used three methods: asking each person to turn the frequency up until the light stopped flickering, asking them to turn the frequency down until flickering began or asking them to say whether the light was flickering over a series of randomly chosen frequencies.

The participants repeated all the tests on three occasions to see if their threshold changed from day to day.

Using the last method, thought to be the most accurate, the average flicker threshold for the whole group was about 50 Hz, but it varied from 34 to 61 Hz (bioRxiv, doi.org/k9hm).

"The range is a lot larger than I expected," says team member Kevin Mitchell, also at Trinity College Dublin. "For most things in the world, that probably wouldn't make any difference to the way they're perceived because they're not moving fast enough. But there are some things moving very fast, where [it] might well make a difference."

"If something were to fly past your eyes very rapidly, but you have a threshold high enough to capture that image, your brain would probably turn it into a blur going in a certain direction," says Haarlem. "Whereas in someone with a very low threshold, that flying object might not be captured at all."

It isn't known what causes people's flicker threshold to vary, but it could involve innate features of parts of the brain that process vision, or of the cells at the back of the eye that react to light.

"There are multiple levels of processing that get an image presented to our conscious perception," says Haarlem. "I think it's a combination."

"This is a very nice study because it's completely new," says biologist Simon Potier. He speculates that people might be able to increase their flicker threshold with training – for instance, if they play a lot of sports involving fast-moving balls, such as squash or baseball. ▮

Marine biology

A harmless way to keep sharks away from beaches

James Woodford

GREAT white sharks avoid places where they have been caught, which might give us a way of deterring them from hunting near swimmers.

It's a flight response, says Paul Butcher at the New South Wales Department of Primary Industries in Australia. "It's the same with almost any animal and the same with sharks." The animals later "resume their normal migratory movements as if nothing ever happened", he says.

Butcher and his colleagues have been using SMART (Shark Management Alert in Real Time) drumlines: baited hooks on buoys located 500 metres off the coast of about 20 popular areas in New South Wales. Each of the 305 total drumlines is equipped with a system that notifies local response teams, who aim to reach any hooked shark by boat within 30 minutes of the animal taking the bait. The lines are set anew each morning and collected later that day so they aren't left overnight.

The teams record the shark's size and health and tag it. They then move sharks deemed as more of a threat to swimmers – great white, tiger and bull sharks – another 500 metres offshore and let them go. Other species, such as hammerhead and grey nurse sharks, are released where caught.

Butcher and his colleagues monitored 36 great white sharks (*Carcharodon carcharias*) that were equipped with dorsal fin-mounted satellite-linked radio transmitting tags after being caught at five sites in 2016. During the first three days after the sharks' release, they all moved away from the beaches where they had been caught and stayed mostly offshore.

PHILIP THURSTON/GETTY IMAGES

A great white shark cruising through Australian waters

"Although sharks gradually moved closer to the shore 10 days after release, 77% of the sharks remained more than 1.9 km away from the coast and an average of 5 km away from where they were tagged," wrote the researchers in their paper.

In addition, the sharks were still being detected, via the tracking equipment, for an average of nearly 600 days after their release, showing that the programme doesn't increase the risk of them dying (*Biology*, doi.org/mbbw).

77%

Proportion of tagged sharks that remained distant from the coast

Since 2015, more than 1100 great whites, with an average length of about 2.6 metres, have been caught on the SMART drumlines, with more than 400 recapture events, says Butcher.

The drumlines are part of a larger attempt in New South Wales to find non-lethal ways to keep great white, tiger and bull sharks away from people in the water. Drones are now flown at up to 50 beaches to look out for sharks and other potential threats during school holidays, and the department runs 37 shark listening station buoys that detect when tagged target sharks pass nearby. This information is then sent to the public via the SharkSmart app.

This suite of tools could one day mean that controversial beach meshing nets, which in New South Wales alone captured 228 animals in the 2022/23 reporting period, can be removed. Of these 228 animals, only 85 were released alive and more than 200 were non-target species, including turtles, dolphins and seals.

David Booth at the University of Technology Sydney says the study's findings are very good news. "And to still be re-sighting the caught and released animals years later is pretty impressive and certainly better than slaughtering them," he says. ▮

Medicine

AI discovers new class of antibiotics to kill resistant bacteria

Jeremy Hsu

ARTIFICIAL intelligence has helped discover a new class of antibiotics that can treat infections caused by drug-resistant bacteria.

"Our [AI] models tell us not only which compounds have selective antibiotic activity, but also why," says Felix Wong at the Broad Institute of MIT and Harvard.

Wong and his colleagues tested the effects of more than 39,000 compounds on *Staphylococcus aureus* and three types of human cells from the liver, skeletal muscle and lungs. The results became the training data for AI models to learn about the patterns in each compound's atoms and bonds. That allowed the AIs to predict both the antibacterial activity of such compounds and their potential toxicity to our cells.

The trained AI models then analysed 12 million compounds through computer simulations to find 3646 with ideal drug-like properties. Additional calculations identified the chemical substructures that could explain each compound's properties.

This allowed the researchers to identify new classes of potential antibiotics and find two promising non-toxic compounds.

Testing in mice showed that the two substances were potential treatments for both methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococcus* – a bacterium that has developed resistance to the drug typically used for treating MRSA infections (*Nature*, doi.org/k9hk).

Only a few new classes of antibiotics, such as oxazolidinones and lipopeptides, have been discovered that work well against both MRSA and vancomycin-resistant *Enterococci*, and resistance against such compounds has been increasing, says team member James Collins at the Broad Institute. ▮

Environment

Much of North America may face electricity shortages starting in 2024

Jeremy Hsu

MORE than 300 million people in the US and Canada face the growing possibility of electricity shortages beginning as early as this year and continuing to 2028.

In a recent report, the North American Electric Reliability Corporation (NERC) – an international regulatory authority – projected that a majority of regions in the US and Canada will have insufficient electricity supply to reliably meet demand during extreme weather conditions. A few may even see interruptions under normal weather conditions.

"I think it is striking that the majority of regions are at an elevated or high level of risk," says Johan Cavert at the Niskanen Center, an environmental think tank based in Washington DC. "This should not be the norm and is quite a frightening assessment heading into the unknowns of another winter."

The report found that North America's peak demand – the highest amount of electricity needed in a given period – is rising faster than at any time in the past five years. The sharp increase also represents a reversal of a decades-long trend involving falling or flat growth in demand.

"This is quite a frightening assessment heading into the unknowns of another winter"

New York state, New England and the entire western US along with some of the most populous Canadian regions, such as Ontario and British Columbia, are at "elevated risk" of experiencing electricity shortfalls in summer heatwaves or winter storms.

But two central US regions have been designated by NERC as being at "high risk" of disruptions even in normal weather. One of these stretches from the US-Canadian border in Michigan and Minnesota to Louisiana on the US's Gulf Coast, and the other encompasses Tennessee along with portions of Georgia, Alabama, Mississippi, Missouri and Kentucky.

It is hard to say how long these disruptions may last, because the industry standards meant to limit shortfalls are based on the "1-in-10 rule". Some interpret this as allowing one day of outages every 10 years, while others suggest it allows for only one disruption event – no matter how long – in that period.

One issue contributing to the problem is the supply of energy, regardless of demand. As power plants that run on fossil fuels are retired, they aren't being replaced with renewable energy sources at the same pace, said Mark Olson at NERC during a media briefing on 13 December.

Challenges around agreeing on routes for transmission lines and getting the required permits have delayed new renewable energy sources being connected to the US power grid.

There has also been a spike in demand for electricity from industries such as cryptocurrency mining, data storage and battery manufacturing. The broader push for the electrification of heating and transport systems is also creating new winter peaks in electricity demand beyond those seen in the summer with increased air conditioning use.

Natural gas has been seen as a "bridge fuel" in the transition to renewable power, but as the winter peak demand has grown, firms have struggled to keep power plants, pipelines and gas production wells operating in cold temperatures due to equipment failures and frozen wellheads.

That means a reliable electricity supply may depend on implementing higher standards for the natural gas industry, said John Moura at NERC during the media briefing. ▮

Technology

Aloe vera plants turned into supercapacitors

ALOE VERA can be used to make a supercapacitor, a device that stores energy and is similar to a battery but discharges power faster. The supercapacitor can also be installed inside a living plant, to be used to power lights or charge low-power devices.

Yang Zhao at the Beijing Institute of Technology in China and her colleagues have built the supercapacitor almost entirely by using different parts of an aloe vera plant, with no additional materials needed apart from a single gold wire.

The outer layer of the aloe leaf, called the rind, was heated to high temperatures to produce activated carbon for making electrodes, while the juice inside was frozen to make an aerogel, which acts as the supercapacitor's energy-conducting electrolyte.

Once Zhao and her colleagues had assembled the capacitor – which is about 4 millimetres by 4 milimetres in size – they installed it inside living plants, including aloe, golden barrel cacti and a species of succulent called *Pachyphytum oviferum* (*Small*, doi.org/k9hj).

"You can appreciate the beauty of the plant, but you can also use the electricity generated from the plant," says Zhao.

PICTURE PARTNERS/ALAMY

Aloe vera is a succulent plant that grows in arid climates around the world

The researchers then used nearby solar panels to charge the plant-based capacitors, which Zhao says transforms the plants into "electronic plants", or e-plants.

The energy-storage capacity was enough to run small lights and it could potentially be used to charge low-power devices like wearable technologies, says Zhao.

She says it could also be useful for providing power to travellers who are lost in remote and harsh environments that host plants like aloe vera and cacti.

It might be possible to make the devices larger and store more energy, but this would require a bigger incision in the plant, which could risk infection and damage. ▮

Alex Wilkins

Quantum physics

We are now more certain about quantum uncertainty

Karmela Padavic-Callaghan

PREDRAG POPOVSKI/MOMENT RF/GETTY IMAGES

IT IS impossible to know both exactly where you are and exactly where you are going in quantum mechanics. This idea, known as Heisenberg's uncertainty principle, has been a key part of studying the quantum realm for decades, but now physicists are even more certain about their uncertainty.

Before quantum physics was developed, researchers seeking to measure an object more precisely simply reached for better measuring instruments. But in 1927, Werner Heisenberg discovered that, when dealing with quantum-scale objects, there is a fundamental limit on how precisely you can simultaneously measure certain pairs of values, such as position and momentum.

Now, Yui Kuramochi at Kyushu University and Hiroyasu Tajima at the University of Electro-Communications, both in Japan, have proved that a version of Heisenberg's uncertainty principle can apply even when measuring just a single variable.

Since the 1950s, researchers have wondered whether Heisenberg's description of uncertainty needs to be modified for systems such as two colliding marbles, in which their combined momentum is conserved – meaning it has the same value before and after they crash together. Could this extra constraint on momentum make it possible to "cheat" the uncertainty principle, letting you measure the position of the two balls exceedingly precisely?

For simple systems where measurements return discrete values such as 0 or 1, the answer seemed to be no. But when it comes to systems like the colliding marbles, position and momentum have continuous instead of discrete values, which makes the maths more complex. Researchers still assumed it wasn't possible to cheat the Heisenberg uncertainty principle, but until now had been unable to prove it. "For that, a completely new approach was needed, and we constructed it," says Kuramochi.

To do so, he and Tajima faced the difficulty of having to carry out calculations and proofs for a very general idea of position: because it can take infinitely many values, it must be represented by an infinite grid of numbers.

"This conclusion applies in all experiments, all measurement interactions, forever"

To get around this, they employed a mathematical trick that allowed them to hide this infinite grid within another mathematical object called a function. They could use this function for most of the proof and then switch back to the true representation of position towards the end, after they had completed all calculations that would have otherwise been intractable (*Physical Review Letters*, doi.org/k9hg).

You can't cheat at quantum marbles

Because the work presents a rigorous mathematical proof, its conclusion "applies completely generally, in all experiments, all measurement interactions, forever", says Leon Loveridge at the University of South-Eastern Norway. There is no way to sidestep it and get a more accurate measurement of the position of a quantum object, he says.

While the work deepens our understanding of the quantum nature of reality, it is unclear whether it can play a role in applications, such as quantum technology, says Loveridge, because the measurement effect is subtle and working out what experiments it may apply to is difficult. Quantum physics is plagued with questions about how tools used in experiments interact with the objects they are measuring, he says. As such, while we may now be more certain about uncertainty, we are still unsure what it means in practice. ▮

Technology

AI learns to recognise objects quickly like a chick

Jeremy Hsu

ARTIFICIAL intelligence may be able to learn from minimal data as efficiently as chicks.

After hatching, many birds learn to identify and follow the first moving object they encounter, a process called imprinting. Samantha Wood at Indiana University Bloomington and her colleagues wanted to know whether AI models called transformers could do a similar task with limited inputs.

"To directly compare learning algorithms to brains, we need to train them on the same experiences," says Wood. So she and her colleagues raised chicks in a box where their only visual stimulation came from a rotating 3D object on a screen. After a week, they showed each chick the same object on one screen many times and displayed an unfamiliar object on another screen. The chicks spent more time near the first object, suggesting they had imprinted on it.

The researchers then created a virtual simulation of the set-up to provide tens of thousands of images for training and evaluating four transformer models. The AI models had just 300 milliseconds to learn from each simulated image – approximating how long biological neurons fire after an image is seen. The AIs learned to recognise a 3D object as quickly as the chicks with about 70 per cent accuracy (arXiv, doi.org/k9hf). ▮

LALIT PANDEY, SAMANTHA M. W. WOOD, JUSTIN N. WOOD

This virtual environment mimicked an imprinting test for baby chicks

Health

The pandemic aged children's brains

Adolescent brains changed faster during covid-19 lockdowns, and the effect was bigger in girls

Grace Wade

THE brains of adolescents showed signs of accelerated ageing during the covid-19 pandemic, with girls affected more than boys. The finding suggests that lockdowns had a disproportionately detrimental influence on brain development in girls.

As the brain develops, the outer layer of its largest region, the cerebral cortex, begins to thin. Hardships in childhood, such as experiencing violence or neglect, accelerate this thinning, which raises the risk of mental health problems, such as despression.

To understand whether the covid-19 pandemic affected this process, Neva Corrigan at the University of Washington in Seattle and her colleagues compared brain scans from children and teens taken before and during the pandemic.

They used scans taken in 2018 from 109 adolescents aged 9, 11, 13, 15 and 17 to create a model of how cortical thickness changes with age. Then, in 2021 during the pandemic, they scanned the brains of a separate cohort of 54 adolescents aged 12, 14 and 16. All participants were from the greater Seattle area and had similar socioeconomic statuses, says Corrigan.

The researchers found that adolescents had accelerated cortical thinning during the pandemic. On average, it was equivalent to four years of ageing in girls, whereas in boys, it was equal to ageing almost two years.

The upheaval seen during lockdowns may have affected child brain development

MATTHEW HORWOOD/GETTY IMAGES

"We're not the first group to report cortical thinning associated with the covid-19 pandemic in adolescents. But this is the first study that has shown these gender differences," says Corrigan, who presented the findings at a recent meeting of the Society for Neuroscience in Washington DC.

Accelerated cortical thinning also affected more brain regions in girls. On average, girls had increased thinning in 35 regions, but boys had it in just three. The regions most affected among girls were those involved in processing visual information, particularly faces. The only overlap between boys and girls involved accelerated thinning in the right and left lateral occipital cortex, areas that help us recognise objects.

"It could be that during the pandemic, that isolation had more of a detrimental effect on the female brain simply because they are more attuned to peer relationships, which are so critical to their brain development," says Corrigan.

"We think you get cortical thinning like this in the brain as a result of exposure to stress," says Ian Gotlib at Stanford University in California, who wasn't involved in the research.

However, it is unclear, based on these findings, if the pandemic-linked increases in cortical thinning are permanent. "It is quite possible that the [acceleration] stops or slows to kind of put these adolescents back on a normal trajectory of brain development," says Gotlib. We won't know until follow-up studies are done, he says. ▮

Immunology

Probiotics seem to reduce long covid symptoms

A DAILY cocktail of prebiotics and probiotics may help treat symptoms associated with long covid.

The condition – in which people have symptoms for months or years after getting covid-19 – is poorly understood, but research has shown that people with it have reduced levels of certain gut microbes. In particular, they lack bacteria that produce compounds called short-chain fatty acids, which regulate immune responses.

Siew Ng at the Chinese University of Hong Kong and her colleagues concocted a mixture designed to boost short-chain fatty acid production. Called SIM01, it contained three probiotics – live strains of bacteria – and three prebiotics, compounds that help beneficial gut microbes grow.

They gave the cocktail to 232 adults; another group of 231 adults took a mixture containing starch and low-dose vitamin C. Both mixtures were taken twice daily for six months. All participants lived in Hong Kong, had previously tested positive for covid-19 and met the US Centers for Disease Control and Prevention's criteria for long covid.

A questionnaire assessing 14 long covid symptoms before and after the study revealed that people given SIM01 were, on average, about 2 to 2.5 times more likely to report alleviation of five symptoms: fatigue, memory loss, difficulty concentrating, general unwellness and gastrointestinal upset (*The Lancet Infectious Diseases*, doi.org/k9hh).

"The probiotic mix enhanced gut microbe diversity and the growth of beneficial gut bacteria"

Analysis of faecal samples before and after the trial revealed SIM01 enhanced the diversity of gut microbes and the growth of beneficial gut bacteria, says Ng.

How this helps with long covid is ambiguous, says Timothy Sampson at Emory University in Georgia. "While it does make sense that the microbiome has the capacity to mediate immune responses… it is not clear that the [immune system] is what is actually underlying the symptoms," he says. ▮

Grace Wade

Mathematics

Game of Life mystery is solved

Mathematicians have found a solution to a problem that has puzzled them for decades

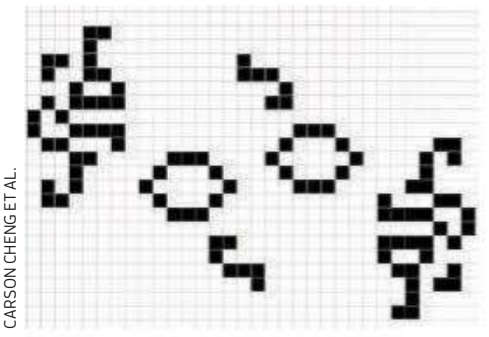
Matthew Sparkes

A LONG-standing mystery about repeating patterns in a two-dimensional mathematical game has been solved after more than 50 years, with the discovery of two final pieces in the puzzle.

Invented by mathematician John Conway in 1970, the Game of Life is a cellular automaton – a simple world simulation that consists of a grid of "live" and "dead" cells. Players create a starting pattern as an input and this is updated over generations according to a few rules.

A live cell with fewer than two neighbouring live cells is dead in the next generation; a live cell with two or three neighbouring live cells remains live; and a live cell with more than three neighbouring live cells dies. A dead cell with exactly three neighbouring live cells becomes live in the next generation. Otherwise, it remains dead.

These rules create evolving patterns of seemingly infinite complexity that throw up three types of shape: static objects that don't change; "oscillators", which form a repeating but stationary pattern; and "spaceships", which repeat but also move.



CARSON CHENG ET AL.

Patterns formed in the Game of Life

One of the enduring problems in researching the Game of Life is whether there are oscillators with every "period": ones that repeat every two steps, every three steps and so on, to infinity. There was a strong clue that this would be true when mathematician David Buckingham designed a technique that could create oscillators with any period above 57, but there were still oscillators missing for some smaller numbers.

Now, a team of hobbyists has filled those last remaining gaps by describing oscillators with periods of 19 and 41 – the final missing shapes (arXiv, doi.org/k9fd).

Team member Mitchell Riley at New York University Abu Dhabi says there are lots of methods to generate new oscillators, but no way has been found to create them with specific periods, meaning that research in this area is a game of chance. "It's just like playing darts – we've just never hit 19, and we've never hit 41," he says.

Riley had been scouring lists of shapes that consist of two parts, a hassler and a catalyst. Game of Life enthusiasts coined these terms for static shapes – catalysts – that contain a changing shape inside, a hassler. The interior reacts to the exterior, but leaves it unchanged, and together they form an oscillator of a certain period.

"You need the reaction in the middle to not destroy the thing on the outside, and the reaction in the middle, just by chance, to return to its original state in one of these new periods," says Riley,

1970

When mathematician John Conway invented the Game of Life

who wrote a computer program to discover potentially useful catalysts. He says there are no real-world applications known for the research and that he was drawn to the problem by pure curiosity.

Susan Stepney at the University of York, UK, says the work uses clever techniques, but isn't the end of research on Conway's creation. "I don't think work on Game of Life will ever be complete. The system is computationally universal, so there is always more behaviour to find," she says. ▮

Zoology

Swimming together lets fish expend much less energy

FISH use half as much energy swimming at high speeds if they are in a school rather than alone.

It has long been thought that swimming in schools reduces energy use and protects fish from predators. But measuring energy use in fish is tricky, partly because they can't generate enough energy using only the oxygen taken in via their gills – aerobic respiration – as they swim faster, so they start to respire anaerobically, using energy reserves stored in their muscles.

So, Yangfan Zhang and George Lauder at Harvard University put giant danio (*Devario aequipinnatus*) in narrow, sealed aquariums where the speed of the water flow can be controlled. They then measured how water oxygen levels changed while individual danios or schools of eight swam at different speeds.

BLICKWINKEL/ALAMY

Giant danio are freshwater tropical fish that prefer to swim together in shoals

The pair kept measuring oxygen levels for 19 hours after the tests because the more energy fish use for anaerobic respiration, the more oxygen they consume later.

At low speeds – between 0 and 3 body-lengths per second – there was little difference in energy use between shoals and single fish. But things changed at higher speeds. At 7 body-lengths per second, for instance, fish in a school used 53 per cent less energy on average than solitary fish. At this speed, schooling fish got half of their energy from aerobic respiration, but solitary fish got just 20 per cent (bioRxiv, doi.org/gs2dd2).

The energy savings mean fish have more energy to search for food or avoid predators, says Shaun Killen at the University of Glasgow, UK. ▮

Michael Le Page

Materials science

Springs made from rusty glass could power nanorobots

Alex Wilkins

TINY tubes of rusty glass are surprisingly springy, which could prove useful in powering nanorobotic devices.

Most metals oxidise when left in the air – when this happens in iron, it is called rusting – which can change their properties, such as making them more brittle.

Yong Yang at City University of Hong Kong and his colleagues found that when they oxidised copper and zirconium nanotubes of metallic glass, which are metals that, like glass, lack a repeating molecular structure, they instead became extremely elastic.

Yang and his team tested their elasticity by seeing how far they could bend the tubes and still have them return to their original position, called the recoverable strain.

"When we deformed these oxidised nanotubes, we found that the recoverable strain can get to 10 to 20 per cent," says Yang. "That's really unusual."

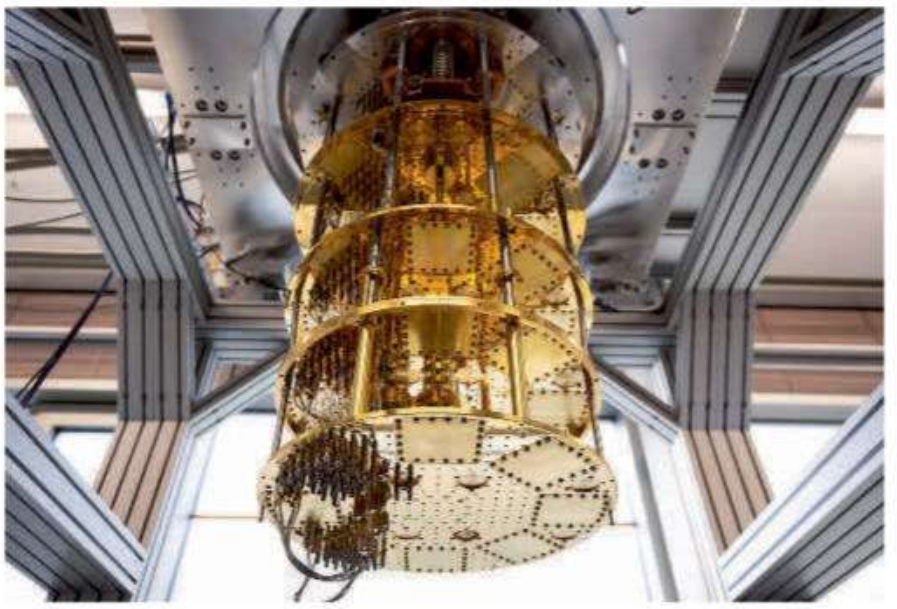
They looked at the oxidised nanotubes using a technique called atom probe tomography and found that instead of forming a layer of oxide on the surface, like most metals, the nanotubes incorporated oxygen throughout their molecular structure, holding the other atoms in place and giving them elastic superpowers (*Nature Materials*, doi.org/k9fc).

So far, the elastic effect in these nanotubes has only been measured at scales 10,000 times smaller than the width of a human hair, which limits their applications to very small electrical components like springs or sensors. However, Yang is hopeful that the effect can be replicated at larger scales, such as with large sheets made up of many nanotubes, so that the material could be used for things like indestructible spectacle frames that aren't at risk of oxidation. ▮

Technology

Google wants to translate physical problems for quantum computers

Alex Wilkins



DPA PICTURE ALLIANCE/ALAMY

Quantum computers don't have many practical uses yet

RESEARCHERS at Google have created an algorithm that can translate complex physical problems into the language of quantum mechanics, which could help quantum computers tackle more tasks.

Once they become powerful enough, quantum computers might become useful for specific jobs, such as breaking encryption or modelling quantum mechanics, but it is still largely unknown how useful they will be for many other scientific problems that classical computers can't help with.

Certain complex problems, such as how best to distribute power over an electrical grid or how a bridge responds to an earthquake, are still best understood using classical physics and computers.

Now, Ryan Babbush at Google and his colleagues have developed an algorithm to translate a large range of classical problems so that they can be run on quantum computers. "There's an important class of classical systems in which we can get an exponential speed-up in simulating the dynamics of those systems on a quantum computer," says Babbush.

Any system that is in a steady state and is then disturbed by some external force, like a Kevlar vest suddenly being hit by a bullet, can be mathematically described by a system of balls and springs, bouncing back and forth, commonly known as Hooke's law.

Many physical problems can be described using this description of balls and springs,

"Many physical problems can be described using a description of balls and springs"

says Babbush, including most wave-like systems such as maps of neuronal activity or light bouncing off a surface.

Babbush and his team realised that the mathematics of these classical spring systems, however complex, could always be expressed as a version of the Schrödinger equation, which describes how any quantum system changes through time.

By looking at similarities between the two equations and using symmetries in the problems, the researchers then worked out an algorithm to translate how far and fast the springs move into the language of the Schrödinger equation and the quantum bits, or qubits, used by quantum computers.

The researchers also showed that the problems their algorithm can solve encompassed every possible problem that can currently be solved on a quantum computer, which means that any other algorithm can also be expressed in the language of the ball-and-spring algorithm, although not necessarily made faster (*Physical Review X*, doi.org/k9d4).

This group contains every possible problem that can currently be solved on a quantum computer, which means that any other algorithm can also be expressed in the language of the ball-and-spring algorithm, although not necessarily made faster.

This is important, says Aleks Kissinger at the University of Oxford, because it means this is firmly outside the purview of classical computers. "Because it's solving some problem about the physics of a classical system, you might at first think, well, maybe there is just some efficient classical algorithm. And they gave very strong evidence that there isn't."

Babbush and his team haven't calculated how many qubits would be needed to run their algorithm, but it is likely to be beyond today's machines. However, it could be one of the first applications that a "relatively modest" error-corrected quantum computer is used for, says Babbush. ▮

Environment

Hurricane damage to forests could release huge carbon stores

Michael Le Page

A SINGLE hurricane hitting New England might result in the release of more than a tenth of all the carbon stored in the area's forests.

The forests of New England – which includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont – have been expanding due to a reduction in farming in the area. Woodlands now cover about 75 per cent of the land area and remove some 16 million tonnes of carbon dioxide from the atmosphere each year.

To work out the potential impact of a major hurricane, Shersingh Joseph Tumber-Dávila at Dartmouth College in New Hampshire and his colleagues looked at the 10 biggest storms to strike New England in the 20th century. The Great New England Hurricane of 1938, for instance, downed 70 per cent of standing trees in places.

The team used computer models to calculate the carbon losses that would occur if the storms happened again with the same wind speeds, or wind speeds 8 or 16 per cent higher – which could happen as a result of global warming.

A storm with the same wind speeds could down trees containing about 120 million tonnes of carbon, while one with winds 16 per cent stronger could release 250 million tonnes or so, the team concludes.

These estimates are conservative, says Tumber-Dávila. For instance, the study doesn't take into account carbon in tree roots.

The release of carbon into the atmosphere would be slow, taking 50 years for 77 per cent of the downed carbon to be emitted, and 100 years for 88 per cent to be released (bioRxiv, doi.org/k9d3).

This isn't just because it takes a long time for trees to decompose. The study assumes that a quarter of the wood is salvaged and some ends up in long-lasting products such as furniture. ▮

Astrophysics

Dark stars may be waiting inside a mirror universe

Jonathan O'Callaghan

DARK matter may occupy a mirror universe, parallel to our own – and, if so, we may be able to spot a strange kind of mirror star.

To explain dark matter, the as-yet undetected form of matter that makes up some 85 per cent of the total mass of the universe, some scientists have proposed the idea of a mirror universe.

This mirror universe would be composed of atomic dark matter, containing dark matter versions of our atoms and particles such as dark protons and dark electrons.

"Under this theory, you would get stars that are like the normal stars we see, like our sun, but they would be made of dark matter," says Isabella Armstrong at the University of Toronto in Canada. "They would emit dark photons."

The Vera C. Rubin Observatory in Chile might be able to spot mirror stars when it switches on in 2025

RUBIN OBSERVATORY/NSF/AURA/B. QUINT

Mirror stars would grow up to about 10 times the size of our sun and also have nuclear fusion taking place at their cores, except with dark hydrogen fusing into dark helium (arXiv, doi.org/k9dz).

"You would get stars that are like the normal stars we see, but they would be made of dark matter"

Normally, such stars would be invisible to us, because they wouldn't emit visible light or interact with matter in our universe. However, Armstrong and her colleagues have now proposed a way they might be seen, if they contain clumps of regular matter within them.

As a mirror star drifts through a galaxy, its gravitational pull might draw in normal matter in the form of gas from nebulae. "That gas begins to heat and emit light," says Armstrong.

Within the invisible mirror star, a "nugget" of visible matter might look quite similar to a white dwarf, the remnant cores of sun-like stars left behind at the end of their lives. But it would emit a very noticeable signal of X-rays and visible light, say the researchers. "So that's how you can tell them apart," says Armstrong.

Rabindra Mohapatra at the University of Maryland says the idea of mirror stars and a dark universe is "plausible". However, if mirror stars ever existed, they would have had shorter lifetimes than regular stars, so they might not have persisted up to now.

Burning fuel

"The density is lower in the mirror world," he says. That means such stars would have used up their fuel more quickly, with lifetimes 10 times shorter than regular stars, and formed dark matter equivalents of black holes or neutron stars at the end of their lives. "Most of the mirror stars should have disappeared by now," says Mohapatra.

The idea of mirror stars and a mirror universe remains extremely speculative. "It's a theory," says Armstrong. "We don't know these objects exist."

But upcoming telescopes might be able to search for them, such as the Vera C. Rubin Observatory in Chile, which will perform a wide survey of the universe starting in 2025 that is projected to discover many faint objects.

Another way to detect a mirror star might be to see its gravitational effect on light that passes through it. "It can bend light on a small scale," says Armstrong. "A telescope like Vera Rubin would be able to look for effects like that." ▮

Health

Slow arms make a tumble more likely

OLDER people may be more at risk of falls because their arms aren't as fast at making movements to help them regain balance if they slip.

Jonathan Lee-Confer at the University of Arizona and his colleagues had 11 older adults (aged 72 on average) and 11 younger adults (aged 25 on average) stride over a Plexiglas sheet embedded in a walkway. They wore a harness to ensure they couldn't hurt themselves and were made to slip sideways.

Motion analysis revealed that the younger participants accelerated their arms 36 per cent faster, on average, than the older adults. Their reaction time was also 310 milliseconds faster (bioRxiv, doi.org/k9gr).

The researchers now want to see what exercises would help boost arm speed. **James Woodford**

ANUP SHAH/GETTY IMAGES

Physics

All snowflakes fall in the same way

EVERY snowflake may be uniquely shaped, but the way they fall seems to be universal.

Dhiraj Singh at the University of Utah and his colleagues have measured the mass, size and density of more than half a million falling snowflakes on a mountain near Salt Lake City, Utah. They built a device to do this that used a sheet of laser light, a hot plate and two cameras. The way snowflakes blocked the light gave the velocity and acceleration, and how they evaporated on the hot plate gave their mass and density.

The device captured vastly different snowflakes, some 20 times larger or denser than others, but the way they accelerated and their terminal velocities fluctuated followed the same statistical pattern (*Physics of Fluids*, doi.org/k9gs). **Karmela Padavic-Callaghan**

Animal behaviour

Chimpanzees recognise photos of their old friends

BONOBOS and chimpanzees seem to recognise photos of former group members – even ones they haven't seen for more than 20 years.

Great apes, such as gorillas, chimpanzees (pictured) and bonobos, have good memories. For example, some chimps can recall the location of specific fruit trees in a forest, and anticipate what happens next in a film they have viewed before. There have also been hints that great apes remember individuals for a long time.

"When we go back to ape populations that we've worked with in the past, we noticed that they seem to recognise and remember us," says Laura Lewis at the University of California, Berkeley.

To investigate how long this social memory lasts, Lewis and her colleagues put 12 bonobos and 15 chimps, all living in zoos in the UK, Japan and Belgium, to the test.

For each animal, the team flashed side-by-side photos of two different apes on a screen for 3 seconds. One of the photos was of an animal that they had lived with at least one year ago and the other was a stranger.

Using eye-tracking technology, the team found that all the apes would look at the images of former group members around a quarter of a second longer on average than they did for the ones of strangers. They would linger even longer on photos of apes that zookeepers said they had positive relationships with.

In one case, a bonobo called Louise seemed to recognise her sister Loretta and nephew Erin after more than 26 years of separation (*PNAS*, doi.org/k9gq).

"That's the longest long-term social memory ever recorded in a non-human animal," says Lewis. Chen Ly

Really brief

IANNI DIMITROV PICTURES/ALAMY

The perfect table for jigsaw puzzles

How large a table do you need to use when you are doing a jigsaw puzzle? To work it out, take the area of the completed puzzle and multiply it by 1.73. This will create just enough space for all the unassembled pieces to be laid flat without any overlap (arXiv, doi.org/k9gt).

A vibrating pill to make you feel full

A tiny vibrating pill can trick the brain into thinking the stomach is full and may create new treatments for obesity. The technique would be less invasive than gastric bypass surgery and potentially cheaper and less prone to side effects than weight-loss drugs like Wegovy (*Science Advances*, DOI: 10.1126/sciadv.adj3003).

Sweater inspired by polar bear fur

A fibre said to mimic the fur of a polar bear may one day feature in space suits and clothing for extremely cold environments. The artificial fibre has already been made into a sweater that is claimed to be as warm as something made from down feathers, but is much thinner (*Science*, doi.org/k9kn).

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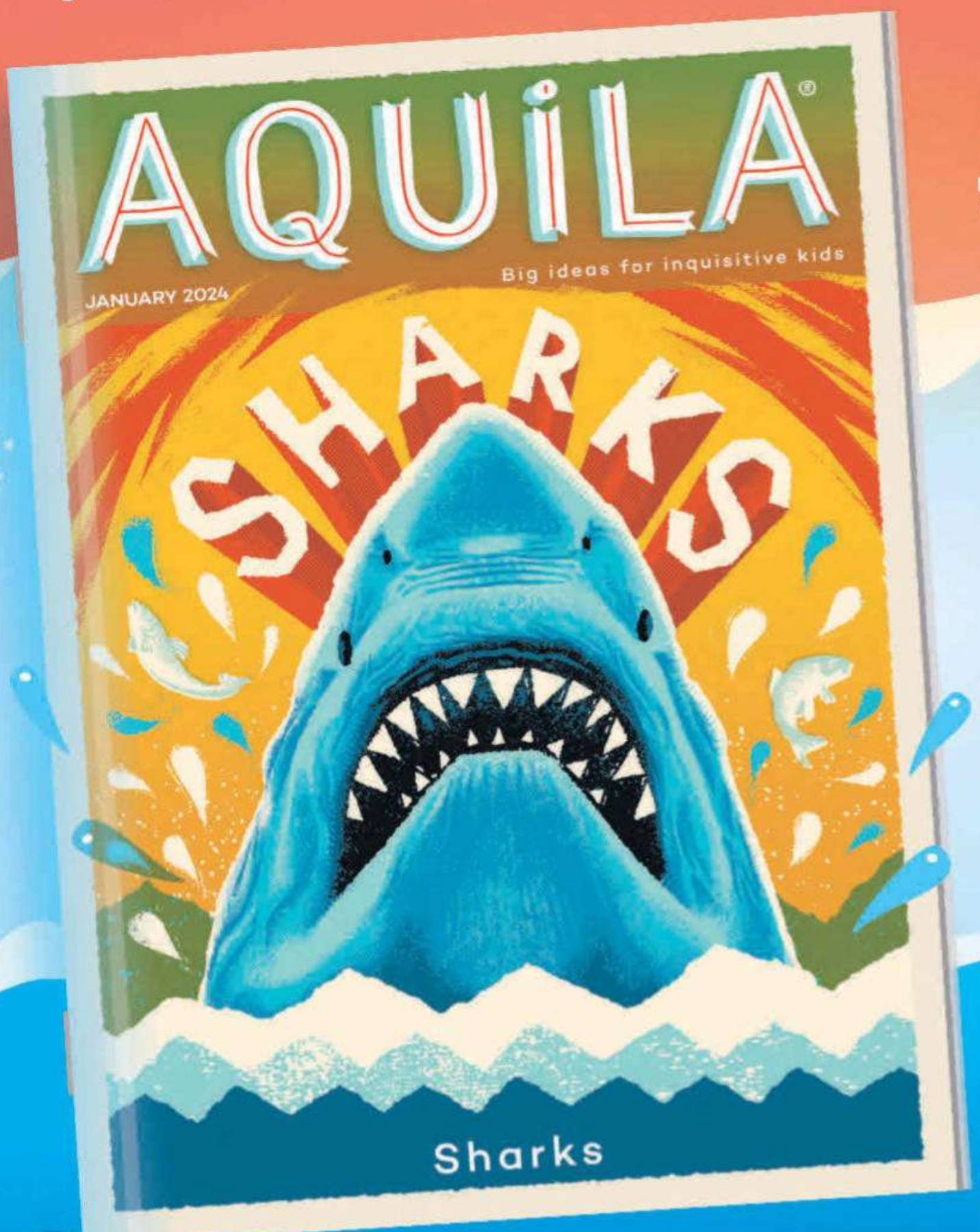

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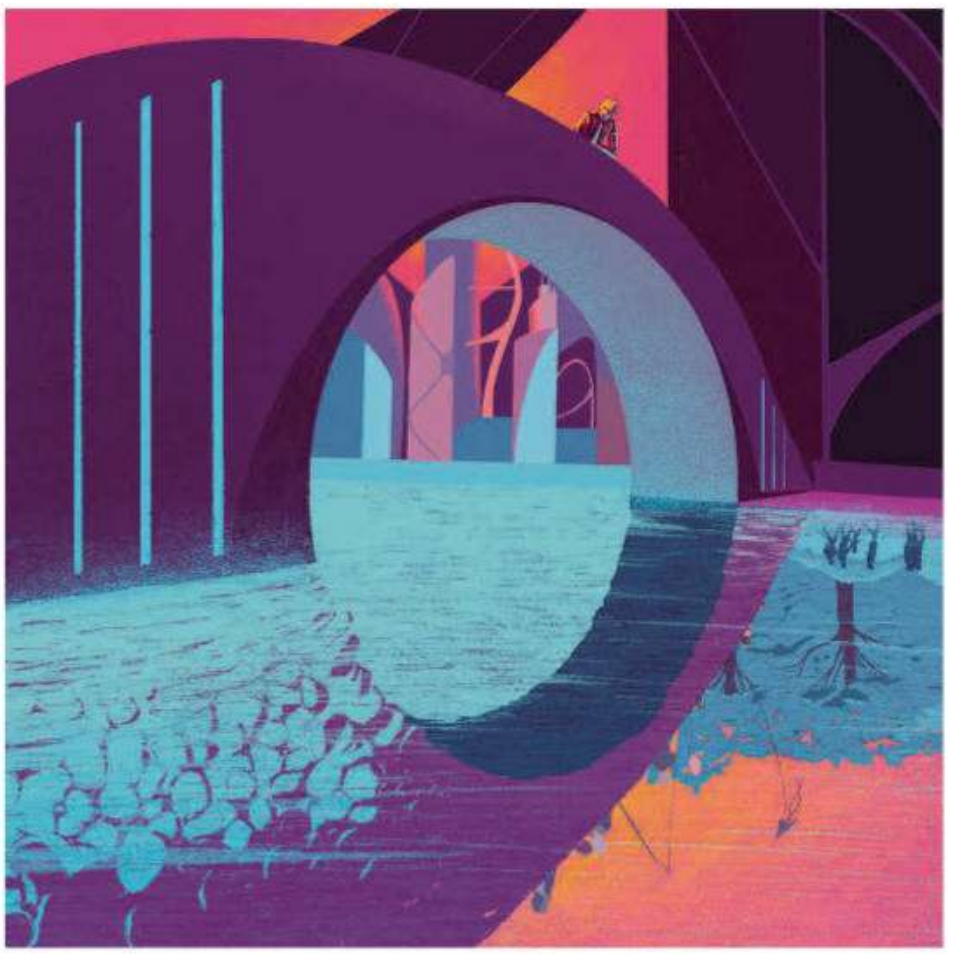
Simon Ings looks forward to a year of new sci-fi films p30

Comment

Go with the flow

Our view of time has changed as we have learned more about the vast span of the cosmic calendar. Yet it is still precious, says **Martin Rees**



SIMONE ROTELLA

IN OUR everyday lives, time is a precious commodity. We can gain it or lose it. We can save, spend or waste it. If our crimes are revealed, we risk doing time.

But it is, of course, something we can measure. Indeed, clocks have, over the centuries, been the high-tech artefacts of their era – the water clock, the pendulum clock, Harrison's chronometer, all the way up to the incredible precision of atomic clocks.

Before there was a reliable calendar of months and seasons, the past was a fog. But this didn't stop efforts to impose fanciful, precise chronologies. According to James Ussher, Archbishop of Armagh in 17th-century Ireland, the world began in 4004 BC. Right up until 1910, bibles published by Oxford University Press displayed his dates alongside the text.

Even in Ussher's time, many people were sceptical that the entire history of Earth's mountains, rivers, flora and fauna could be squeezed into 6000 years. In the 19th century, Charles Darwin's genius was to recognise how natural selection could have transformed primordial life into the amazing variety of creatures that have crawled, swum or flown on Earth. But he guessed that this higgledy-piggledy emergence, proceeding with no guiding hand, needed at least 100 million years; geologists inferred a similar span.

Radioactive dating now tells us that the sun and its planets condensed 4.5 billion years ago from gas in the Milky Way galaxy – itself part of a vast cosmos that emerged from a fiery "beginning" about 13.8 billion years ago.

What happened before the beginning? In the 5th century, Roman Empire philosopher St Augustine sidestepped the issue by conjecturing that time itself was created with the universe. The "genesis event" is as mysterious to us, as it was to him.

However, our perspective on the future has no such limit. We know that our sun will shine for another 6 billion years before its nuclear fuel runs out. And the expanding universe will continue, perhaps forever, destined to become ever colder, ever emptier.

Maybe we aren't even at the halfway stage in the progressive emergence of complexity in the cosmos. Any descendants of life on Earth who witness the sun's demise (having long before then gained the ability to live at a safe distance) may be as different from us as we are from slime mould.

But even in the immense timescape that modern cosmology reveals, extending billions of years into the future as well as the past, this century is special. It is the first in the 45 million centuries of Earth's history when one species – ours – can determine the entire planet's fate. We have entered the Anthropocene. Today's decisions on environment and energy, empowered by our scientific knowledge, will resonate through future centuries.

Despite our awareness of the aeons to come, our planning horizons have shrunk because our lives are changing so fast. The political focus is on the urgent and immediate, and the next election. Medieval cathedrals took a century or more to complete. There are few efforts by public or private sectors to plan more than two or three decades ahead – or to build structures that will, as the cathedrals have done, offer inspiration for a millennium.

Humans may also acquire the capability to redesign themselves via genetic modification, or to deploy "cyborg" techniques that enable them to implant in their progeny the advantages of electronic computers. This evolution via "secular intelligent design" could operate far faster than Darwinian selection.

Perhaps our remote descendants will have a much-enhanced lifespan; they might even become near-immortal. Would they, like us, "spend and save" time as a scarce resource? Or would an overabundance lead to ennui? Only time itself can tell.

Martin Rees is the UK's Astronomer Royal. His latest book is *If Science is to Save Us*

Artificially intelligent

Robotic lab techs Autonomous labs can perform experiments thousands of times faster than a human and they don't need to sleep. Are they the future, asks Alex Wilkins

Alex Wilkins is a *New Scientist* reporter covering artificial intelligence, physics and space. Artificially intelligent is a column that cuts through the hype and looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

Alex's week

What I'm reading
Filterworld *by Kyle Chayka, an exploration of how algorithmically suggested content has left almost no part of our culture untouched.*

What I'm watching
Apichatpong Weerasethakul's Cemetery of Splendour, *a mysterious meditation on sleep, war and past lives.*

What I'm working on
I've been trying to get my head around black holes for a couple of New Scientist *pieces.*

This column appears monthly. Up next week: Chanda Prescod-Weinstein

A COMMON experience for many PhD students working in labs – the glass beaker and fume cupboard kind – is to feel like a glorified robot. So much science, especially the testing of new materials that students are often left to carry out, can require repetitive drudgery that feels like a waste of time and talent.

Artificial intelligence and actual robots might seem like an obvious way to offload some of this menial work, but, for a long time, the complexity of even simple scientific experiments put this beyond reach. Yet now, a quiet revolution is under way in the form of the autonomous lab.

At the heart of so many scientific disciplines that concern themselves with finding new substances, from better batteries to powerful drugs, is a problem of scale. Our ability to predict possible new structures has grown enormously, like with Google DeepMind's protein structure-predicting AI AlphaFold, but our capacity to test whether these structures exist and are correct hasn't caught up.

This problem is surprisingly pervasive. In November last year, Google DeepMind released another model, called GNoME, that predicted potentially millions of new crystal structures that could be used for things like better solar panels or computer chips. But until they are made in the real world, which could take months in the lab with a team of people, they had to remain as predictions.

Self-driving labs, which tend to consist of some assemblage of robotic arms, testing equipment and an AI overseer, can perform experiments thousands to millions of times faster than a person – and they don't need to sleep. They can measure properties, assess results and tweak future rounds of experimentation depending on what they find. "We can do more science in less time," says Alán Aspuru-Guzik at the University of Toronto, the head of a self-driving lab collaboration called the Acceleration Consortium.

Google DeepMind shared its AI crystal predictions with a group at Lawrence Berkeley National Laboratory in California that is developing a self-driving lab, called A-Lab, capable of autonomously synthesising and testing new crystal structures. The A-Lab team managed to create 41

"BEAR, which boasts a 3D printer and robotic arm, can run 50 experiments a day without human supervision"

of the predicted crystals in real life, though the results have received pushback from some scientists, who say that the group hasn't correctly identified the materials.

Researchers are devising self-driving labs to do science in a surprisingly wide range of disciplines: in August, for example, a group at Boston University discovered the most energy-absorbing structure ever measured, which could find use in bike helmets and car crumple zones, after searching through possible designs using its Bayesian experimental autonomous researcher, or BEAR for short. Boasting a 3D printer, a robotic arm, scales and a hydraulic press, as well as an AI coordinator, BEAR can run 50 experiments a day without human supervision.

In November, researchers at the University of Science and Technology of China gave real Martian meteorites to their robotic chemist and asked it to autonomously find oxygen-producing catalysts, using only the minerals it could extract from the meteorites. They saved their robot some of the drudgery by using an AI system to predict which combinations of elements might make the best catalyst, narrowing down a list of millions of testable materials to just 200. It worked, finding a catalyst comparable to the best available catalysts on Earth from 10 years ago.

All of these examples are impressive displays of engineering and how far AI has come, but none of the results has been world-changing yet. We still haven't seen a better battery or solar panel deployed on a commercial scale that was made possible because of a discovery by a robot gripper, rather than a human hand. Many argue it is just a matter of time until we do, as these methods become more commonplace, but thinking that AI will solve all our problems is an easy trap to fall into.

For all the promise that self-driving labs hold, there are many questions too. Humans are still needed to interpret results, and this can be open to controversy, like in the case of the A-Lab project. The machines must also be told by a human where to look and what project to focus on, and currently lack the general exploratory powers of a human researcher. And though the labs are developing rapidly, it is hard to keep up with the massive increase in AI predictions.

As Andy Cooper at the University of Liverpool, UK, told me last year: "The world's capability to predict and calculate things, and use machine learning to extrapolate further, is evolving faster than the robotic capability to look for the materials." ▮

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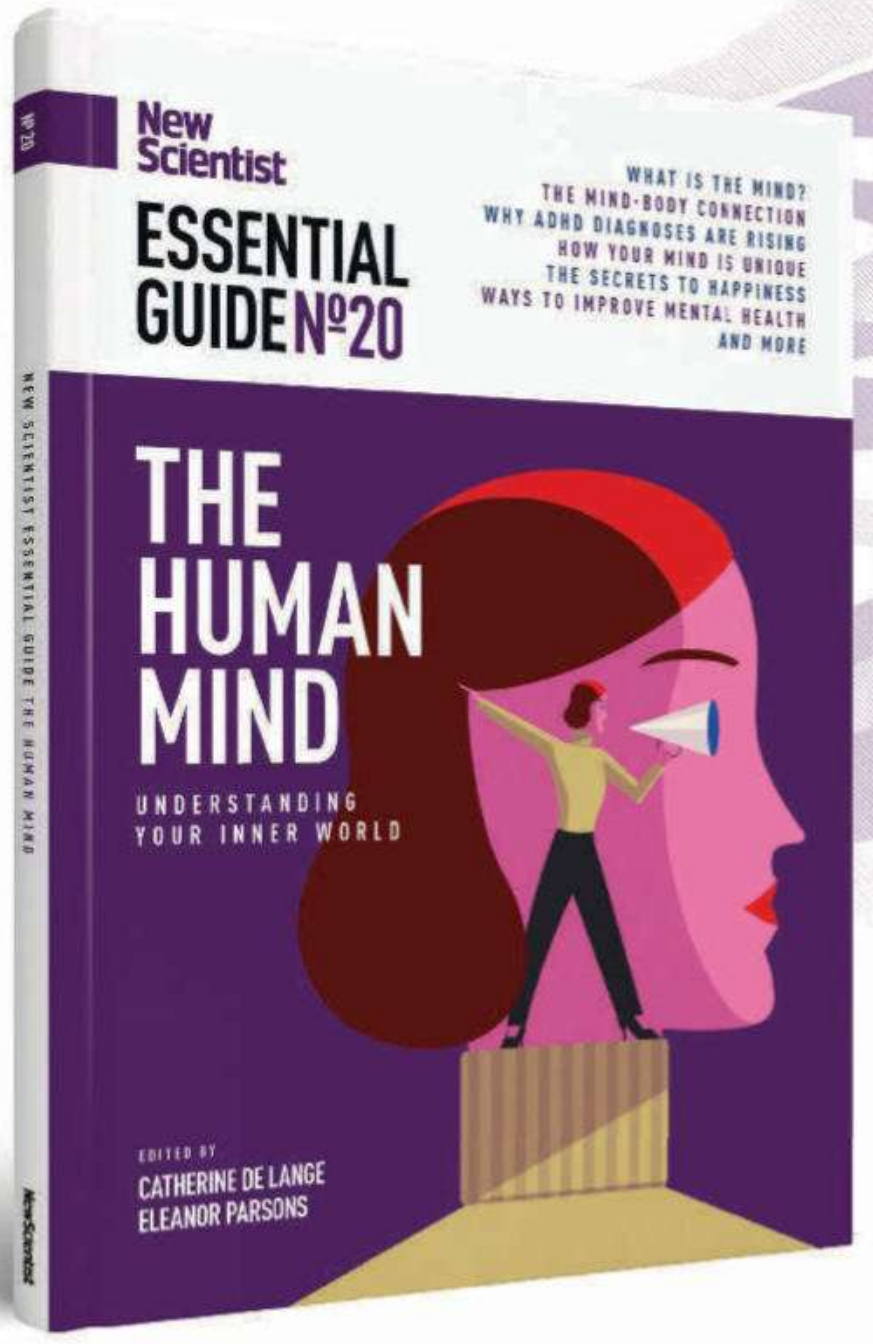

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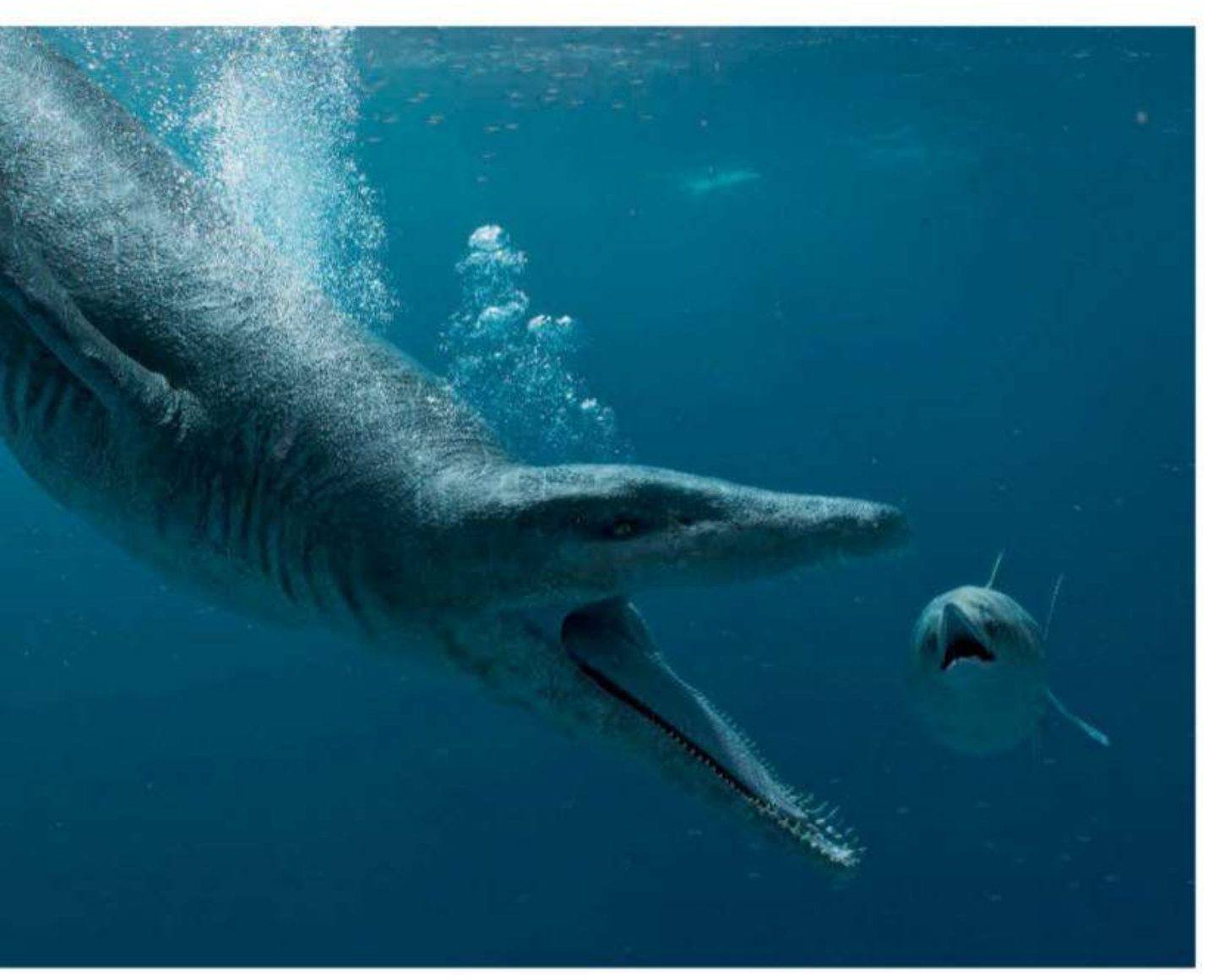

Toothsome find

BBC Studios

AN ENORMOUS Jurassic pliosaur skull extracted from a cliff in Dorset, UK, is offering scientists a wealth of new information about these sea reptiles. "It's very likely a new species," says Judyth Sassoon at the University of Bristol, UK.

The fossil was the subject of a new documentary, *Attenborough and the Giant Sea Monster*, which premiered on BBC One on 1 January and will air on PBS in the US in February. The skull is so well preserved that CT scans revealed the sensory pits on the snout (bottom left) were connected to blood vessels and nerves, allowing the pliosaur to detect changes in pressure and hunt prey in murky waters (bottom right, in a CGI image from the documentary).

There is hope that the rest of the fossil is still intact in the cliff. "There may be evidence on its skeleton of how it met its death," says Steve Etches, who led the team to extract and prepare the skull. Etches is shown at top left, examining the snout with David Attenborough, left, in a still from the documentary.

Surface scans of the specimen have helped scientists estimate the strength of its bite. Emily Rayfield, a palaeontologist at the University of Bristol, suggests its bite force would have been twice that of a saltwater crocodile, one of the most powerful known bites. Evidence of trihedral teeth, with two sharp cutting edges and striated grooves, is shown at top right. The grooves are believed to stop a vacuum forming when the teeth are plunged into prey, allowing the pliosaur to repeatedly and swiftly bite down, and further cementing its place as one of the deadliest predators of its time. The skull is on show at the Etches Collection in Dorset, UK.

David Stock

Editor's pick

Do AIs need a good sleep to function well?

16/23 December 2023, p 44

From Andrew Taubman, Sydney, Australia

It seems possible that all animals with brains need to sleep and dream or, like us, they would presumably lose touch with reality. Perhaps the same is true of artificial intelligence? Researchers might like to build in periods of enforced inactivity or who knows what AI might do.

Use CO_2, not warming, as gauge of climate change

9 December 2023, p 10

From Fred White, Nottingham, UK

Why chase the theoretical date of a global temperature rise of 1.5°C when carbon dioxide levels can be measured in real time anywhere?

Adopting temperature rise as a measure of the climate emergency is akin to using rates of skin cancer as a measure of the extent of the ozone hole. CO_2 is the issue and failing to factor emissions into goods and services is, and always has been, the problem that has got us into this mess.

Worms can save us from pointless leaf raking

9 December 2023, p 44

From Ann Smith, Churchdown, Gloucestershire, UK

At last, an advocate in James Wong for leaving nature to deal with leaf fall on your lawn. I would like to add that worm species are also important recyclers. In the UK at least, anecic earthworms form vertical burrows and drag leaves underground. No need to do any work ourselves. I never do!

Collapse of oil states would spark major problems

9 December 2023, p 11

From Geoff Harding, Sydney, Australia

The collapse of national income for states reliant on coal, oil and gas production and export could lead to frightening scenarios.

The problem of climate refugees fleeing countries or areas such as Pacific islands due to devastating climate change impacts are very likely to be compounded by many millions of people displaced by economic collapse and consequent privation, as income from fossil fuels dries up. Future COP climate meetings must consider this imminent problem and devise means of economic support.

Modern society seems pretty fragile to me

9 December 2023, p 36

From Dave Neale, Bedford, UK

I sincerely hope that Peter Turchin is right in his predictions of the growing resilience of modern-day societies, but I fear that few of the civilisations of the past 5000 years on which he has based his conclusions would have had communication networks that could spread panic in minutes, along with just-in-time supply chains that result in bare shelves after an accident on a major road.

Combine that with successive governments whose planning for a pandemic is to hope one never happens, and I suggest we have a very fragile supply infrastructure.

To find signs of alien life, look closer to home

25 November 2023, p 40

From John Healey, Adelaide, South Australia

If we are trying to find alien life, why go to all the trouble of searching for biosignatures on remote exoplanets? Several novelists have pointed out that, if aliens are as enthusiastic tourists as we are, they will leap at the chance of visiting Earth, where, by pure coincidence, the sun and moon are about the same size in the sky. This produces the spectacle of annular solar eclipses.

So, just go to such an event and watch for suspicious characters, in particular those staying apart from the Earthlings and perhaps wearing baggy clothes to disguise their non-human shape. They might also be green.

Quite prepared to cough up extra for hidden costs

2 December 2023, p 40

From Dave Holtum, Bath, Somerset, UK

Graham Lawton's article on the true cost of goods when emissions are factored in led me to wonder about the true cost of a copy of *New Scientist*. The only applicable research I could find was done in Sweden by the KTH Royal Institute of Technology's Centre for Sustainable Communications in 2007. It compared print and e-newspapers. Using this, I came up with a figure of about 2 kilograms of carbon dioxide per printed copy of *New Scientist*. The cost of carbon can be anything from £5 to £200 per tonne depending on the source. Using an average of £100 per tonne would add 20 pence to each printed copy of *New Scientist*. I would happily pay that, so long as it went towards carbon offsetting.

I really think sentient robots are a bad idea

9 December 2023, p 40

From John Wade, Edinburgh, UK

Has Josh Bongard considered the consequences of embodied AI if he does manage to develop artificially intelligent robots that can feel and think with true, human-like understanding?

The present level of AI already raises many serious problems – social, economic and psychological. The primary safeguard is that you can turn it off if things are going wrong. Could you turn off a sentient robot? This project seems to cross a line that suggests robots will become feeling beings in a totally new and disturbingly unrestricted sense.

From Matthew Tucker, Sydney, Australia

Having read the call to develop embodied AI, I couldn't help but wonder if there were only some way that two ordinary people – a man and woman for instance – could get together in the privacy of their own homes and undertake some kind of experiment that resulted in a fully functioning intelligence, body included.

This could even be the breakthrough needed for general intelligence, not to mention consciousness. Get to work scientists. We can work out how to make them corporate slaves later.

Why were the Swiss so prone to long covid?

2 December 2023, p 36

From Stephanie Woodcock, Carnon Downs, Cornwall, UK

You report that by far the highest known rate of long covid has been in Switzerland, a wealthy country with a northern temperate climate. This rate variation points to unknown factors being involved in developing long covid. Does some factor put certain wealthy Westerners at greater risk? Intriguingly, among the earliest recorded outbreaks of the similar illness myalgic encephalomyelitis/chronic fatigue syndrome, or ME/CFS, was one in the 1930s among soldiers in a Swiss encampment.

For the record

The earliest supernovae were glimpsed in the galaxy GS-z12 (2 December 2023, p 13).

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Dark sky at night...

At a novel sci-art festival celebrating the many cultural and scientific needs for dark skies in a time of serious light pollution, **Alex Wilkins** looks for hope

Festival
Tårup Dark Sky
Biennial science and art festival
Funen, Denmark

IN A village on Denmark's third-largest island, a group of astronomers, artists, performers and enthusiasts gather to celebrate the night sky, and to mourn its loss. Its remote location could have made it a tricky place to hold a festival to honour the heavens, but the village of Tårup (population 290) is unique: its residents have chosen to have no street lights, making it an enclave of darkness.

It is a bad time to be a stargazer. Cities full of bright lights are constantly expanding, their stray glow making the stars more difficult to see, while the dazzling satellites littering Earth's orbit do the same by reflecting sunlight back at our planet.

I am a guest at Tårup Dark Sky, which is an attempt to change all that. This is a new biennial science and art festival, held for the first time in September 2023 on the island of Funen. It aims to highlight what is being lost, pairing scientific talks explaining just how much we learn from the stars with artistic events offering an emotional counterpart.

One astronomer attending the festival was Ivalu Barlach Christensen from the Max Planck Institute for Radio Astronomy in Bonn, Germany, who studies the chemistry of star-forming regions. She grew up in Greenland, where the stars and the northern lights were a constant. "The stars have always been right there and visible, and I had a lot of questions," she says, adding that if she hadn't been able to see those stars as a child, she might never have become an astronomer.

TARUP DARK SKY FESTIVAL

Above: installation *Pigs in Space* by HC Gilje; Left: A still from *!AITSA*

As Christensen talked, standing in one building of the converted pig farm where the festival was based, the sun began to set, ushering in a sky full of stars. Once the sun disappeared, the full moon made it difficult to discern some constellations. But the sheer number of stars was far greater than it would be near most of the world's major cities.

Such views are becoming rare, and Christensen worries about what we are losing collectively. "Looking up kind of triggers questions above ourselves. It's sad that not a lot of people get to experience that," she says.

Things are changing, albeit slowly. Author and self-taught cosmic dust hunter Jon Larsen had some good news from his native Norway, where he says building regulations must now take light pollution into account by, for example, facing street lights away from the sky. "There's an awareness about these things, because everybody likes to see the stars," he says.

There are also many global efforts to protect dark skies. For instance, the International Dark-Sky Association is a US non-profit organisation with thousands of members working globally to certify and protect areas that are optimal for stargazing.

At the festival, art installations and performances were hard at work using the night sky as inspiration. Artist Nanna Debois Buhl's installation *Stellar Spectra* paired archival prints of 19th-century astronomer Margaret Huggins's work on spectroscopy, with bands of colour typically produced by a prism, like red, blue, yellow and green.

In one old pig shed, I discovered an installation called *Pigs in Space* by HC Gilje. His work explored light's relationship with shadow through a collection of pillars and moving lights, which cast a complex series of shadows on the shed wall. Though the festival's juxtaposition of art and science could feel unrelated to dark skies, overall they were a refreshing complement. "It's absolutely intertwined," says Larsen. "In science, you can't go anywhere without imagination and fantasy."

Some events showed that close connection at work in other ways. Take South African film-maker Dane Dodds's documentary *!AITSA*, which had multiple screenings in a makeshift cinema in one of the old barns. The film follows the construction of some of the Square Kilometre Array telescopes, a constellation of nearly 200 dishes in one of South Africa's remotest regions, aiming to reveal secrets about the first moments after the big bang.

But *!AITSA* (a South African exclamation of praise or surprise) is as concerned with the placing of

How to find dark skies

You don't have to travel to a remote Danish village to find dark skies. The International Dark-Sky Association (IDSA) has certified regions of darkness in 22 countries worldwide, with smaller chapters of IDSA for local nations, if you are looking to get into local dark-sky activism. The group's website also has a handy map.

If you are in the UK, great spots include the Yorkshire Dales, Exmoor National Park or Eryri (Snowdonia) in Wales. These areas have been designated by IDSA as dark sky reserves, some of the darkest places in the world. And in the US, head for the Sawtooth mountains in central Idaho or Big Bend National Park in Texas, which are both dark sky reserves.

those telescopes on the ancestral homeland of the Afrikaans-speaking descendants of the |Xam people. Dodds interviews them about their cultural traditions and attitudes about the night sky. It makes for a moving exploration of different systems of knowledge and meaning as international mega-projects collide with ancient traditions.

The closing moments of the film feature a performance of lithophones, sculpted sections of rock that produce wonderful sounds and harmonics when they are hit by another, smaller rock – and put me in a meditative mood. Having also heard how stars are born and revelling in cosmic

"The festival pairs the science of stars with art offering an emotional counterpart"

dust, I was feeling spaced-out.

"A festival like this is quite absurd," says Larsen. "You know, we are out in the farmland in the countryside of Denmark. If you had asked people in Copenhagen, 'Is there any culture in Funen?', they would say, 'No, there's just farmers". But here we are with avant-garde artists and scientists, together for a couple of days. Hopefully, having some beer and enjoying everything. Why not?"

Each day, after the talks and performances were over, there was a stargazing session led by a professional astronomer. I couldn't tell whether it was the stars, unfamiliar environment or the homemade cider, but, huddled around the campfire, a wave of sadness washed over me. How much longer would we be able to enjoy such truly dark skies? ▮

Order and disorder

It's time we fell in love with thermodynamics, says **Karmela Padavic-Callaghan**

Book

Molecular Storms
Liam Graham
Springer Link

UNLIKE quantum or particle physics, thermodynamics rarely makes headlines, yet it is crucial for understanding how life arose and how the universe containing that life will end. This is at the heart of *Molecular Storms: The physics of stars, cells and the origin of life* by physicist-turned-economist Liam Graham.

His grand tour of the physical world leaves little unexamined, starting with simple systems of gas molecules in a box, moving to the smallest, simplest living cells, then on to whole planets. Graham does a stunning job of connecting everything to the state of disorder we call entropy and to the driving force behind structures everywhere – the "molecular storms" of his title.

He offers a more precise definition of entropy in terms of the microscopic states that a system can support given its macroscopic constraints – such as how the arrangement of water molecules in a glass of water are constrained by the shape and volume of the glass. Thanks to molecular storms, the system fluctuates between states. And at the level of nature's smallest building blocks, everything is constantly pushed around by those storms.

Then there is the second law of thermodynamics: entropy in an isolated system can increase, but can never decrease. Graham emphasises that, while this law can be derived from statistics rather than from forces or other familiar concepts in physics, it still underlies so much of the phenomena around us.

His book can get challenging for readers of popular science, but it teaches them to ask how everyday objects contribute to the entropy of the universe. Take what happens when you remove the plug after a bath. Though the violent swirl produced – a vortex – may not seem like it, a careful accounting of all possible arrangements of water molecules in the bath shows it is an unexpectedly low-entropy structure.

And what about the "nanomachines" copying DNA inside your cells? They create information-rich, specific molecules – surely they must be working to decrease entropy? Unravelling the puzzle of the complex mechanisms that keep them from breaking the second law explains their very nature.

***Molecular Storms* ends by discussing life's origins, adding in all its complications, ones that wouldn't work if they couldn't somehow, sometimes, decrease local entropy in at least some parts of a vastly disordered universe. While much remains open, Graham is certain of one thing: we need thermodynamics to make sense of the world's wild complexities.** ▮

Water escaping via the plughole creates a low-entropy vortex

JUDITH COLLINS/ALAMY

New Scientist *recommends*

Corryn Wetzel
Reporter
New York

New York's American Museum of Natural History is fond of giants, from its colossal blue whale model to a towering stegosaurus skeleton. Its latest exhibition, **The Secret World of Elephants**, celebrates the power of modern and ancient pachyderms.

Turning up, I was greeted by a full-size model of a woolly mammoth shedding its winter coat (above), and I poked at melon-sized replicas of elephant poo while learning how these animals process 100 kilograms of food a day.

Interactive panels let visitors probe the lives of elephants, from their key role in ecosystems to the deep social relationships they forge. To my surprise, I discovered that they use low, rumbling sounds to talk to each other through vibrations in the ground.

Following sobering details on the dangers wild elephants face, the exhibition points to new ways we can share the planet with them, from protecting wild spaces to reducing poaching.

ALVARO KEDING/AMERICAN MUSEUM OF NATURAL HISTORY

The film column

New Year, new apocalypse

From a thriller set on the International Space Station to Nicolas Cage reeling from monsters, end days are everywhere. Luckily, 2024 also has some cracking blockbusters and intriguing independent features, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram @simon_ings

BLEECKER STREET

The International Space Station is the setting for a post-apocalyptic thriller

FOR a creative industry that has the whole of human experience and an entire planet to draw inspiration from, the film business is extraordinarily attracted to dreaming up scenarios for end times.

Consider these forthcoming offerings. Russian and American astronauts on the International Space Station witness a nuclear apocalypse on the planet below and are ordered into deadly conflict with each other in Gabriela Cowperthwaite's thriller *I.S.S.* (US 19 January; UK dates to be announced).

And in *Arcadian* (dates to be announced), Benjamin Brewer – who was lead visual effects artist for *Everything Everywhere All At Once* – teams up with Nicolas Cage for a feature about a father struggling to protect his sons from a monster-haunted apocalypse.

Not even the past is safe from global destruction. *Roswell Delirium* (expected in March) is director-producer Richard Bakewell's curious amalgam of 1980s nostalgia, alien abduction and nuclear apocalypse.

A few fictional valleys on, Milla Jovovich and Sam Worthington struggle for air in *Breathe* (expected in May), director Stefon Bristol's action thriller set in a deoxygenated future.

> **"A palate-changer to watch out for is *Mickey 17* from Bong Joon-ho (of *Parasite* and *Snowpiercer* fame)"**

As our last days approach, we should perhaps applaud the efforts of bigger studios to stop (or reverse) time. *Mad Max* director George Miller's *Furiosa: A Mad Max Saga* (24 May) and the upcoming *Kingdom of the Planet of the Apes* (also 24 May) at least look amazing.

But can we really watch as John Krasinski wrings the final drop of tension from *A Quiet Place,* as producer and co-writer of *A Quiet Place: Day One* (28 June)?

Or as *Alien: Romulus* (expected 16 August) adds its few cents to Ridley Scott's heap of xenomorph lore? This constant recycling of movies is enough to make us despair.

Happily, other blockbusters are available. Two-parters completing in 2024 include Denis Villeneuve's *Dune* (1 March) and Zack Snyder's *Rebel Moon* (19 April), billed as a more grown-up *Star Wars*.

And elsewhere, *The Electric State* (dates to be announced) adapts Simon Stålenhag's book of the same name. If it follows the story of the novel, expect an elegaic journey through the aftermath of a war and the waste from a society in which people abandoned themselves to virtual reality. The film is from the Russo brothers (directors of several Marvel movies).

Another palate-changer to watch out for is *Mickey 17* (29 March), from writer/director/producer Bong Joon-ho (of *Parasite* and *Snowpiercer* fame), about a spacefaring engineer regrown and reissued after every industrial accident. Starring Robert Pattinson, the film is being kept under wraps, but I have high hopes: Edward Ashton's original novel was wonderfully sly.

Broad comedy turns up for certain in *Distant* (19 January), a planetary survival caper directed by Josh Gordon and Will Speck, who made the uproarious Will Ferrell vehicle *Blades of Glory*.

Spaceman (dates to be announced), on the other hand, directed by Johan Renck, starring Adam Sandler and based on a 2017 novel by Jaroslav Kalfař, should bring an altogether more heartfelt and melancholy approach to our explorations of the great beyond. ▮

Simon also recommends...

Films

Figures

Rhett Cutrell

Fornever Productions

I must admit that I am beginning to steer away from saving-the-planet stories in favour of documentary detail. In Figures *(1 January), Rhett Cutrell follows herpetologists Matej and Zuzana Dolinay across West Africa in pursuit of deadly (but ultimately rather charming) snakes.*

The Sasqualogist

Joseph Granda

Merkel Media

Another intriguingly off-piste film is Joseph Granda's The Sasqualogist *(6 June), a mockumentary that leads us into the Colorado Rockies in pursuit of the secrets of human identity.*

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SIMON PRADES

Fire in the hole!

As well as making history, the first attempt to explore a magma chamber could pave the way to unlimited clean energy, says **Graham Lawton**

ICELAND is one of the most boring countries in the world. That is meant as a compliment, not an insult. The island nation is dotted with thousands of boreholes drilled deep into the rock to extract geothermal energy. They will soon be joined by another, which will be anything but boring. "We are going to drill into a magma chamber," says Hjalti Páll Ingólfsson at the Geothermal Research Cluster (GEORG) in Reykjavík. "It's the first journey to the centre of the Earth," says his colleague Björn Þór Guðmundsson.

Well, not quite the centre. Some magma chambers – underground reservoirs of molten rock – lie just a few kilometres below Earth's surface, putting them within reach of modern drills. They occasionally leak magma to the surface, where it spews out as lava. That is exactly what was starting to happen, to spectacular and devastating effect, around the town of Grindavík in southern Iceland, as this story went to press. The trouble is, we don't normally know where magma chambers lie. "No geophysical technique has been shown to satisfactorily locate magma reservoirs," says John Eichelberger at the University of Alaska Fairbanks.

Now, though, Ingólfsson and his colleagues have struck it lucky. They have stumbled across a magma chamber and have advanced plans to do the unthinkable and deliberately drill into it. The project will do no less than make scientific history, providing our first direct opportunity to study the hidden liquid rock that Earth uses to build its continents. Along the way, it may also discover a path to supply the world with unlimited cheap and clean energy.

Until recently, nobody had tried to drill into a magma chamber, not only because we generally don't know where they are but also because of the obvious risks. "You could never really propose to drill into magma," says Eichelberger, who has researched volcanoes for decades. "People would laugh at you and say, you'll start an eruption. And besides, you can't find it." But in 2009, that changed, dramatically and unexpectedly, at a volcano called Krafla in north-east Iceland.

It is one of the world's most active volcanoes, sitting right on top of the mid-Atlantic ridge at a point where the Eurasian and North American tectonic plates are pulling apart, and it has blown its top 29 times since Iceland was settled in the 9th century. The most recent activity was between 1975 and 1984, when it erupted nine times, an episode known as the Krafla fires.

Those events were studied intensely by earth scientists, including volcanologists Katia and Maurice Krafft, who tragically died a few years later during an eruption in Japan, a story told in the 2022 film *Fire of Love*. The work at Krafla led to the discovery of a potential magma chamber around 3 to 7 kilometres beneath the volcano. Páll Einarsson at the University of Iceland mapped seismic waves emanating from tectonic activity associated with the eruptions and found two "shadows" – spots where the waves were significantly weaker or missing altogether. This can be caused by a liquid – possibly magma – absorbing them, though there are other explanations. At the very least, it was a hint that there was something interesting down there.

Knife through butter

In 2000, the Icelandic Deep Drilling Project (IDDP), an industry-government consortium, decided to bore into the volcano to explore the possibility of tapping extremely hot and pressurised "supercritical" water for geothermal power. They picked a spot where a recent geophysical survey had suggested that the magma chamber – if it existed – was at least 4.5 kilometres down. In 2008, Iceland's main power company Landsvirkjun, which runs a geothermal plant at Krafla, started drilling.

The plan was to go down to 4000 metres in order to get close enough to the magma but still remain at a safe distance. Work went smoothly until early 2009. Then, at a depth of around 2000 metres, the drill started inexplicably struggling. At 2104 metres, it suddenly plunged down like a hot knife through butter and then abruptly stopped. The engineers withdrew it 13 metres and tried to lower it again, but it refused to budge. Days later, samples from the borehole showed that it had been gummed up by a type of ultra-hard volcanic glass called obsidian. The only explanation was that the drill had penetrated a magma chamber and molten rock had flooded in as it was withdrawn, plugging up the opening. "When we drilled into magma, it was totally unexpected," says Bjarni Pálsson at Landsvirkjun, who was the project manager.

"I and some other scientists who deal with volcanoes were just amazed that somebody had actually drilled in the magma, and got samples of magma," says Eichelberger. It later transpired that similar accidental encounters had happened twice before, once in the Menengai caldera in Kenya and also at a volcano called Kīlauea in Hawaii. This was proof that it was both possible and safe to drill into magma without causing an eruption.

Landsvirkjun used the Krafla borehole for ›

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nine months to generate electricity. But the wellhead at the surface eventually overheated to 450°C – a world record, apparently – and the firm had to cool it down using cold water, with explosive results. Dramatic footage from the time shows vast clouds of black smoke billowing from the borehole (pictured, below). This wasn't a volcanic eruption, but the cremated remains of the drill and its steel casing as it was being obliterated by the magma, says Ingólfsson. It soon stopped and turned into an invisible haze of super-hot steam. "That basically destroyed the well," says Eichelberger.

But if life gives you magma, make magma-ade. Pálsson and his team decided to exploit the fact that the magma chamber was so accessible to realise a long-standing goal among geoscientists to explore one. In 2014, they set up the Krafla Magma Testbed (KMT) project. A decade on, they are almost ready to start drilling.

The closest encounters geoscientists have had with molten rock up to now came from a series of expeditions in Hawaii run by the US Department of Energy. In 1959, the Kīlauea volcano erupted, filling its crater with lava to a depth of 130 metres. Over the next 30 years, the department took samples from the lava lake as it gradually solidified. "We cored into that, and it was quite amazing that you could core into liquid rock," says Eichelberger, who cut his teeth on the project. But that was as far as it went. The next step was supposed to involve finding and drilling into a magma chamber, but the researchers failed to locate one.

"The plan is to drop scientific instruments into the magma"

Yet now the quest for magma is back on. "This is what we'd been dreaming about," says Eichelberger. "I had given up that we would ever succeed in this. But there it was."

The first goal of KMT is to drill into the magma and make scientific discoveries. Starting in 2026, the project will break ground close to the original borehole and drill towards the chamber. It will take around two months to get there, progressing laboriously through the volcanic rocks until the drill hits pay dirt. First and foremost, the researchers want to build their fundamental understanding of magma and the chambers that hold it. "We don't have any direct knowledge of what magma chambers look like, which is crucial in understanding volcanoes of course," says Paolo Papale at Italy's National Institute of Geophysics and Volcanology in Pisa. The little we do know largely comes from studying lava. But lava and magma aren't the same. A lot of gas is released as molten rock comes to the surface and is then exposed to the atmosphere as lava, both of which change its chemical composition. "Being able to go into the crust and sample magma would give us huge knowledge," says Ingólfsson.

KRAFLA MAGMA TESTBED/YOUTUBE

When the borehole at Krafla in Iceland overheated, the result was a vast cloud of smoke billowing over the landscape

As well as doing this, the researchers want to drop scientific instruments into the magma. At a bare minimum, that means temperature sensors. They would also like to take pressure readings, but that is more challenging, says Ingólfsson: developing sensors, as well as drilling equipment that can withstand the intense heat, pressure and acidity, will take more time – hence the 2026 start date.

The plan is to drop instruments into the magma and leave them there for as long as they survive. The drill will cool the magma as it goes in, solidifying it to obsidian that will entomb the sensors. But the scientists will then allow it to heat up and melt again, releasing the sensors into liquid magma. "We hope to be able to have a direct measurement at least of temperature, which has never been done before," says Ingólfsson. The borehole will stay open, allowing further monitoring and experiments to take place over many years. KMT describes it as the world's first magma observatory. "It's the Large Hadron Collider of earth science," says Papale.

The team will also measure the temperature

JARROD RYAN JOOSTE/SHUTTERSTOCK

The caldera of Krafla volcano. Some 2 kilometres beneath it lies a magma chamber

gradient as the solid rock transitions into magma. One of the big surprises of the earlier, unexpected encounter between drill and magma chamber at the site was how rapidly that occurs. "The theory was that you would go through solid rock and into what is called the brittle-ductile boundary, where the rock would be starting to get a little bit softer and more elastic because of the heat," says Ingólfsson. That was expected to occur over hundreds of metres, but, with Krafla, it was just a few.

Prodding the beast

The nature of Krafla's magma is also of great interest. Most volcanoes spew out basaltic lava, which solidifies to form the volcanic rock basalt. Iceland is basically a colossal lump of porous basalt. But the samples taken in 2009 show that Krafla also holds rhyolitic magma, which contains more silica, is much more viscous, tends not to erupt and solidifies into the more durable rocks granite and rhyolite. These are the substrates for continent building, but the process isn't well understood, says Eichelberger. "This is a chance to understand how our planet makes continental crust," he says.

A second goal is to improve eruption forecasting. At present, that is largely done using seismometers and other instruments on the surface, but it is a very inexact science. "When something happens at a volcano, when the ground starts to move, we call it volcanic unrest," says Papale. "It means something is happening, but we're lacking direct information on what. We need to relate our surface measurements to dynamics occurring down there."

To further that goal, the project aims to prod the magmatic wasps nest and see what happens at the surface. For example, the scientists might inject fluids into the chamber to alter the pressure and temperature and then measure the results. "We can do real experiments on a real volcanic system and volcanic unrest, so we understand the meaning of the signals that we record at other volcanoes," says Papale.

Such knowledge could have provided more advanced warning of the eruption at Grindavík and will be useful in other places in danger. One example is Campi Flegrei caldera, which is similar to Krafla but lies in a densely populated part of Italy. "This has big consequences for active volcanoes and the risks associated with them," says Papale. "We have millions and millions of people at risk of their life, big infrastructure, industrial buildings and so on." The experiments may also improve the detection of unknown magma chambers. "When we intersect it on purpose, we can learn how to recognise the presence of magma at shallow level," says Papale.

The final goal is to make a quantum leap in geothermal energy production. Once the scientific well is under way, the researchers will start on a second one to use as a test bed for a new energy source that could supply the world with vast amounts of clean electricity for next to no cost.

Iceland and many other volcanically active countries, notably Kenya and the US, already tap hot geothermal fluids to drive turbines and generate electricity. But, at the moment, this captures only a fraction of the available energy. A fossil fuel plant uses steam at about 450°C, but standard geothermal fluids are at about 250°C. "It's quite inefficient at those low temperatures," says Eichelberger. "So there's an interest in trying to develop super-hot geothermal."

Before it got mired in magma in 2009, the Krafla borehole hit geothermal fluids at around 900°C and a pressure roughly 500 times that of the atmosphere. This generated around 10 times as much power as a standard borehole. The technical know-how developed by KMT, and the improved ability to discover magma chambers, might lead to a new energy technology called near-magma geothermal, where wells are drilled into the brittle-ductile zone and tap extremely hot, highly pressurised water to drive turbines. You might think that these wells would inevitably have to be dug much deeper than normal geothermal wells, and therefore they would be pricier. But that isn't so. Standard geothermal plants in Iceland, which cost about $5 million upfront, have wells that descend about 2.5 kilometres, which is actually deeper than the Krafla magma chamber. For context, these existing geothermal plants produce electricity that costs 4.3 US cents per kilowatt-hour, about a sixth of the cost of electricity in the UK.

Many places on Earth have the potential to exploit this nascent near-magma geothermal method, not least the mid-Atlantic ridge in the Atlantic Ocean, a place where Earth's crust is being ripped apart naturally. "Think about all the rift zones in the oceans," says Ingólfsson. "We could use the experience and knowledge of advanced offshore drilling platforms from oil and gas and couple it with knowledge of getting energy directly from magma." He foresees great platforms all around the ocean, harvesting energy from magma holes and using it to produce low-carbon synthetic fuels that could be shipped to shore.

That is for the future. But KMT could make it a reality. "There are endless opportunities," says Ingólfsson. "The only thing we need to do is to learn how to tame this monster." Well, that and a lot more boring. ▮

Graham Lawton is a features writer at *New Scientist*

Ready to blow

Neutrinos from the next nearby supernova could explode our best model of particle physics – if we are ready to detect them, says **Stuart Clark**

KEN CHEN

ON A clear night, watching the stars in an inky sky, one word comes to mind: calm. The starlight seems to speak of stability and permanence. And yet, hidden from the naked eye, the wider cosmos is a place of relentless upheaval. Every 10 seconds or so, somewhere in the universe, a star reaches the end of its life and caves in on itself before exploding with cataclysmic ferocity.

For all their ubiquity, we still don't fully understand what triggers core-collapse supernovae. But we do suspect that elusive particles called neutrinos play a key role, and that observing them in the unimaginably extreme conditions inside a supernova could betray the exotic matter and forces that would lead us to a deeper theory of particle physics. "There's just so much information in supernova neutrinos," says Joachim Kopp, a theorist at Johannes Gutenberg University in Mainz, Germany.

The problem is that supernovae close enough to Earth to spill their secrets are rare. The most recent one came in 1987, and the 25 neutrinos we were able to capture from the blast continue to mystify researchers to this day – which explains why so many are so excited by the new generation of neutrino detectors currently being built around the world.

The idea is that when the next nearby star goes supernova, we will be ready. But it is a race against time because that is already long overdue. "You can imagine how exciting it will be if we actually observe one of these bursts," says Kate Scholberg, a neutrino physicist at Duke University in North Carolina. "And how terrible it would be if we miss it."

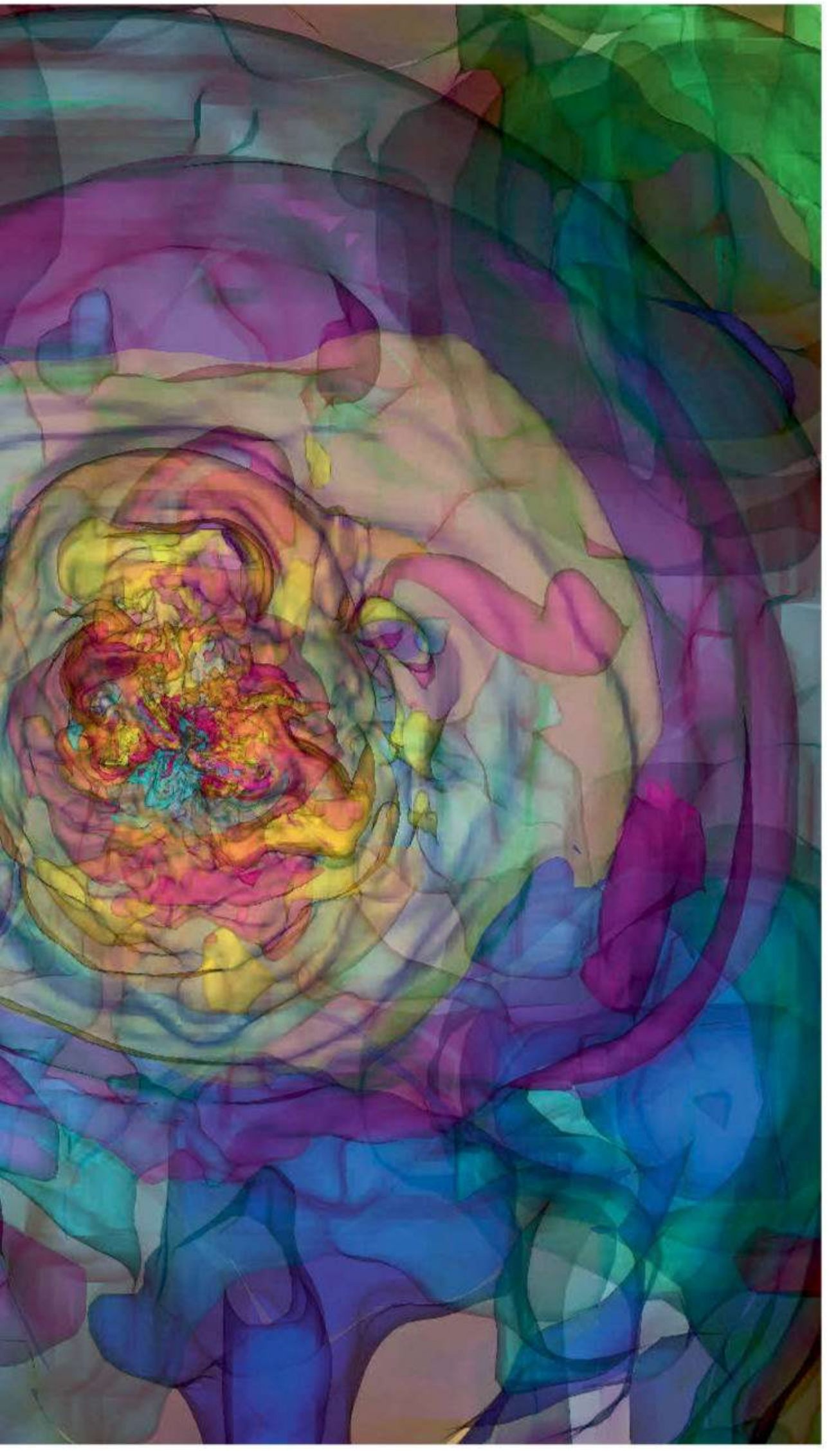
Neutrinos were predicted by calculation long before being found in experiments. In 1930, Wolfgang Pauli showed that a particular form of radioactive decay, known as beta decay, seemed to lose energy, a clear violation of known physics in which energy can be neither created nor destroyed. To restore normality to the universe, Pauli proposed that an as-yet-undetected particle must be at work to spirit the energy away. It was called the neutrino – Italian for "small neutral one" – as it was thought to be massless and to have no charge.

That is why people call neutrinos ghostly particles. Tens of billions of them pass through your fingertip every second unnoticed. They only reveal themselves when they occasionally interact with other particles via the weak nuclear force. This also means that they are difficult to investigate in particle physics experiments and, as a result, we know relatively little about them.

Strange shape-shifters

But these shy particles are arguably the key to whatever theory supersedes the standard model of particle physics, our current best description of the fundamental particles and forces of nature, which we know is incomplete. According to the standard model, neutrinos are massless particles that come in three distinct flavours: electron, muon and tau. But early neutrino experiments that monitored the versions of this particle produced by the sun, as well as by cosmic rays in the upper reaches of Earth's atmosphere, deduced that neutrinos could transform between flavours. That threw up a problem, as this shape-shifting is only possible if they have mass, the origin of which can't be explained by the standard model.

Physicists have concocted a scheme for these so-called neutrino oscillations to occur, as a kind of add-on to the standard model.



A simulation of the turbulence inside a superluminous supernova, with colours showing densities of matter

It includes the idea of three discrete masses for the particles. Depending on the energy of the neutrino and the distance over which it has travelled, a probability can be calculated that it will change flavour. These probabilities depend on the masses, but, confusingly, the three possible masses don't match the three flavours. Physicists don't know the value of these masses, either. So the strange ways of neutrinos, and the clues they might contain about interactions with long-sought hypothetical particles, continue to elude us.

With this in mind, particle physicists are busy constructing several multi-billion-dollar neutrino experiments around the world. In the US, there is the Deep Underground Neutrino Experiment (DUNE); in Japan, there is Hyper-Kamiokande (Hyper-K); and in China, there is the Jiangmen Underground Neutrino Observatory (JUNO). When switched on within the next decade or so, these facilities will fire intense neutrino beams made in particle accelerators through warehouse-sized vats of liquid. Occasional flashes of light emanating from these vats will signal that a neutrino has interacted with the liquid. By varying the energy of the neutrino beam, and with each experiment having a different distance over which the beam has travelled, researchers hope to precisely grasp how neutrinos shape-shift.

These liquid vats are also sensitive to neutrinos arriving from outer space. The immense energy released from a collapsing star produces vastly more neutrinos than a terrestrial particle accelerator: 10^{45}, to be precise. What's more, the energies imparted to these neutrinos are far larger than anything that can be made here, offering a fresh angle on how neutrinos mutate. "[Supernova neutrinos] are the kind of neutrinos that I'm most excited about detecting," says Scholberg, who is a DUNE collaborator.

This isn't just a numbers game, though. The ultra-dense conditions inside a core-collapse supernova could also reveal new particles and interactions that would leave their imprint on the signals from these events. Take the most recent nearby supernova, SN1987a, the light from which suddenly appeared in the night sky on 23 February 1987. At the time, neutrino detectors were just starting to mature, so detectors in Japan, the US and the then Soviet Union captured only a handful. "That was a tremendous detection, [giving] enormous ›

Will we be ready for the next nearby supernova?

The most recent supernova we know of in our own galaxy was observed way back in 1604, in the constellation Ophiuchus, and was visible even during the day for three weeks. Astronomer Johannes Kepler famously studied the exploding star, which served as further evidence that the night sky wasn't fixed, but could occasionally change.

Given that the average rate of supernovae in our galaxy appears to be one every 50 years or so, it seems that the Milky Way is long overdue for another. One possible explanation for this is that stars have exploded on the far side of the galaxy, from where their light would have been obscured by the thick clouds of dust that lie along the plane of the galaxy.

In any case, when the Deep Underground Neutrino Experiment (DUNE) and other neutrino detectors come online, there will no longer be anywhere for supernovae to hide. That is because the neutrinos they produce interact only very weakly with other particles, so they would reach our detectors on Earth.

"The neutrinos go right through the matter of the galaxy, so we can absolutely see supernovae on the other side," says Kate Scholberg at Duke University, North Carolina, who is part of the DUNE experiment.

Scholberg is working on a real-time data-processing tool to ensure we don't miss valuable signals from stellar explosions. DUNE's detectors produce a huge amount of data, so it would be utterly impractical to continuously capture this on the off-chance that a nearby star explodes.

Instead, the tool will automatically recognise a supernova signal as it unfolds and start the recording process. In the 10 to 20 seconds that the neutrino blast from such an event lasts, experimenters hope to detect thousands of supernova neutrinos (see main story).

The number of neutrinos that researchers detected from supernova SN1987a, which came from a star in the Large Magellanic Cloud, a nearby companion galaxy to the Milky Way, pales in comparison at only 25.

information, but it was still only a couple of dozen neutrinos," says Scholberg. They nevertheless allowed physicists to put new limits on the existence of all kinds of novel theoretical particles, including axions, dark photons and another type of neutrino known as a sterile neutrino – all of which are contenders to be the stuff that makes up dark matter, the mysterious source of gravity invoked to explain our observations of how galaxies rotate, clump together and form in the first place.

"Just imagine how much we're going to learn from the tens of thousands of events that we'll have when the next galactic supernova explodes," says Kopp.

But there is a problem. Compared with particle accelerators, which make carefully controlled neutrino beams, the cores of supernovae are chaotic and poorly understood. Only by simulating star explosions accurately will physicists be able to make sense of data from a nearby supernova – and there are already signs that these computer simulations are still missing a key component.

A supernova is imminent when a giant star runs out of nuclear fuel. In a matter of milliseconds, the once-furious stellar core, typically about the same diameter as Earth, stops generating energy and collapses into a ball just 50 kilometres across. In the process, electrons that circle each nucleus are forced into the centre of each atom, where they combine with protons to produce neutrons. Each one of these reactions creates a neutrino that escapes into space. "The neutrino is actually the dominant energy-loss mechanism for the supernova," says Peter Graham, a particle physicist at Stanford University, California.

But when we model core-collapse supernovae in a supercomputer, the star often fails to explode. The problem with these simulations is that when the core collapses, the rest of the star begins to fall downwards onto it. As this material strikes the core, it creates a shock wave that starts to propagate outwards through the in-falling matter. If this shock wave reaches the surface, the star explodes and the supernova is born. The trouble is that the surrounding matter is falling so quickly that the outward-moving shock wave stalls. Hence, in current simulations, it never reaches the star's original surface and the supernova never quite happens – which suggests there is something missing from our understanding of how these explosions proceed.

Secret forces

In recent years, theorists have had more luck. By allowing a minuscule percentage of the escaping neutrinos to be absorbed by the shock wave, the wave gains enough energy to carry on and explode the star. Yet they still have trouble matching their simulations to real events.

For one thing, according to an analysis published in June, our best simulations aren't consistent with supernova SN1987a. "We thought since all modern theories agree with each other more or less, in terms of [the number of neutrinos produced in the supernova], then surely they must agree with SN1987a data," says Shirley Weishi Li at Fermi National Accelerator Laboratory in Illinois, who co-authored of the analysis. "To our surprise, it seems like just counting neutrino detections – the simplest thing you can do – showed some disagreements."

Modern simulations predict that we should have detected more neutrinos in 1987. It is a counterintuitive twist that the more sophisticated our computer simulations of supernovae have become, the more they have diverged from the one and only actual supernova for which we have data. "It seems like the data has a lot to say about modern simulations," says Li.

The missing ingredient could be our imperfect understanding of neutrinos, suggests Li. For one, neutrino oscillations aren't implemented in modern simulations. Some extended models of particle physics also include "secret" interactions between neutrinos that cause them to scatter from one another at the extremely high densities expected in a supernova. These interactions are introduced to try to explain why neutrinos have mass. A study published in August found that if these interactions do take place, then this could be observed in a nearby supernova

because such behaviour would lengthen the time over which the neutrinos leave the core. Instead of flying out directly, they would jostle each other. "They influence each other in highly non-trivial ways. This is one of the big puzzles of neutrino physics," says Kopp.

The fact that modern supernova simulations predict too many neutrinos may already be a hint of new particles beyond the standard model, suggests Li. "The generation [of such particles] would take away some of the predicted neutrino luminosity and make it match better with the data," says Li. She isn't the only one thinking in this direction. Graham says that particles of dark matter escaping the explosion undetected "could easily be the dominant energy-loss mechanism of the supernova, even more than neutrinos".

In effect, a supernova could be a dark matter factory. Depending on their mass, these particles would be made in abundance during the collapse of the core. They would then immediately diffuse out of the core. As a result, the number of neutrinos arriving at Earth would fall away more quickly than the current simulations suggest. This effect could also reveal the character of the dark matter in a way that traditional observations simply cannot. "Supernovae are really good laboratories for looking for particles [that only couple through the weak nuclear force]," says Graham – as many theorists suspect dark matter does.

There is another tantalising possibility that could emerge from such a neutrino signal. If we see the neutrino blast stop suddenly, it would indicate that the star itself has collapsed into a black hole, as nothing can escape its interior. Observing this up close would be a first for astronomers, and if they could then figure out how it happens, it could help to unlock a host of puzzles about how galaxies work. It could even offer extreme tests of fundamental theories of nature. "My favourite astrophysical scenario would be if there's a collapse to a black hole, so we can actually see that in real time," says Scholberg.

The prospect of a nearby supernova is, without doubt, exciting. The neutrino data we collect could well be unique in terms of its quantity and quality, illuminating how a supernova explosion grows, as well as the enigmatic workings of neutrinos, black holes and dark matter. But will nature oblige?

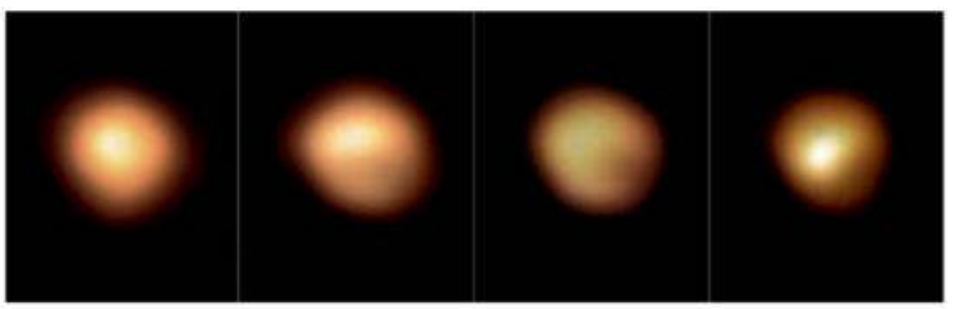
There are signs that it might. In 2019, the red giant star Betelgeuse, which is around 700 light years from Earth, dimmed unexpectedly by a factor of three. This led to speculation about whether its energy generation was becoming unstable in the prelude to a supernova. By April 2023, however, the star had returned to normal and many astronomers have begun to favour an explanation that postulates a large dust cloud formed from matter released at the surface of the star, temporarily obscuring our view – rather than a sign that the star has run out of fuel and is on the verge of collapse. We just have to wait and see.

There are other red supergiant stars only hundreds or thousands of light years from Earth – Eta Carinae and Antares, for example – that astronomers are keeping a close eye on. But the truth is that the next big one could come from anywhere in the Milky Way, or a neighbouring galaxy, at any time.

Scholberg hopes that the next galactic supernova bides its time for just a few more years, at least until the next generation of neutrino detectors is ready. "My dream is to have a supernova with DUNE, JUNO and Hyper-K running all at the same time," says Scholberg. Then again, at the other end of the scale, it could come too late because there is no guarantee that one will explode in the lifetime of these experiments. We have to get lucky, in other words (see "Will we be ready for the next nearby supernova?", page 38). If we do, says Kopp, capturing and interrogating supernovae neutrinos could end up being "by far the most important legacy of these experiments, even outshining all the fantastic accelerator-based neutrino physics that they are going to do".

The message is clear: keep calm and carry on building the detectors. ▮

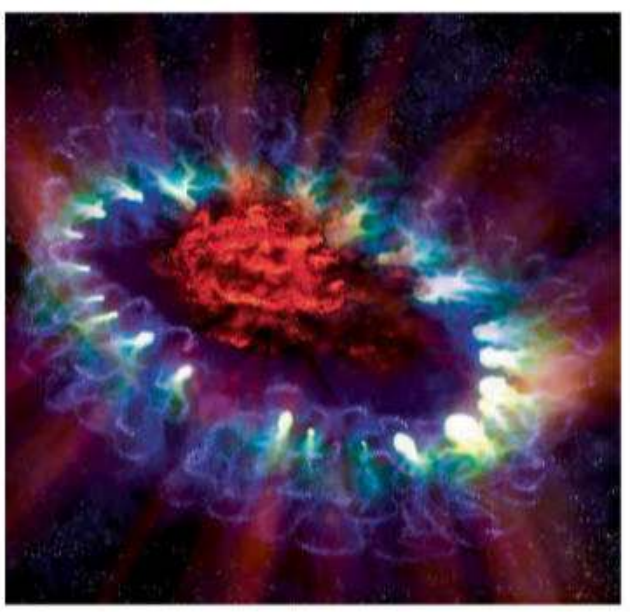
CERN



ESO/M. MONTARGÈS ET AL.

Betelgeuse may be pulsating (below), hinting the star could soon go supernova. But will the DUNE neutrino detector (above) be ready to collect data?

The halo from SN1987a, the last nearby supernova



SCIENCE HISTORY IMAGES/ALAMY

Stuart Clark is a consultant to *New Scientist*. His latest book is *Beneath the Night: How the stars have shaped the history of humankind*

Anxious times

The birth of a child is a happy period for most, but overwhelming anxiety can take hold for some parents. Why does this happen and what can we do about it, asks **Tina Knezevic**

DANNIELLE BAHRI had done everything she could to prepare for having her first child. She registered for CPR classes. She signed up for a breastfeeding course. She took careful note of the advice and warnings her healthcare providers gave her.

But, despite her diligence, she felt anything but calm when she finally brought her daughter home. She had recently learned about sudden infant death syndrome, and the condition consumed her thoughts. She found herself staying up all night to watch her daughter breathe and taking her temperature obsessively, worried she would overheat and die suddenly. Even nine months later, she would stand over her crib at least three times a night to check she was breathing.

It isn't uncommon for parents to feel anxious for the first few months. After all, bringing a newborn home presents a huge change in their lives. But Bahri felt her fear was out of control. As she watched her husband get over their shared worries, she wondered why hers weren't going away.

Like most parents, Bahri, who lives in Canada, had been warned about postnatal (or postpartum) depression, but no one had told her about postnatal anxiety. Masked by the focus on depression and the assumption that these are normal worries every parent faces, this hidden condition has a huge impact on parents and their children. But as more and more people speak out about their experiences of crushing anxiety after becoming parents, and it rises up the medical agenda, researchers are beginning to figure out the causes and explore the best treatments.

By some estimates, postnatal anxiety affects 20 per cent of women. Some researchers think that its prevalence is rising, while others attribute this to increased reporting of the condition, perhaps partly because more celebrities are going public with their experiences. Actor Laura Prepon said she broke a tooth when she started grinding her teeth in her sleep due to anxiety after having her first child, while actor Busy Philipps described not being able to go into a grocery store because of an overwhelming sense of panic.

It isn't just mothers who are affected. Much as with postnatal depression, fathers are at risk: up to 18 per cent develop some type of anxiety following the birth of a baby. Partners and adoptive parents can also have the condition.

Most people are aware of the symptoms of postnatal depression: sadness that continues unabated, crying, a lack of joy. "The symptoms of postpartum depression are a departure from what people expect when someone has a baby, which is for it to be a happy time," says Ryan Van Lieshout, the Canada research chair in perinatal mental health.

Postnatal anxiety, by contrast, may not be immediately visible in new parents because it is normal to have a few worries after having a baby. But for some people, that worry can become all-consuming, persisting beyond the first few months. Some, like Bahri, stay awake all night. Some become intensely fearful about leaving their baby with another person, even their partner or parents. Others start avoiding certain activities or rarely leave the house for fear of something happening to their baby or themselves.

For Kelley Hassanpour, a diagnosis didn't come until she registered her son for day care when he was 13 months old. She stopped sleeping and started having trouble breathing because she worried her son wouldn't receive the same care she had been providing. "I just didn't recognise it, and I think as a first-time mom, it was really hard to tell the difference between what's normal worry and what was not normal worry," she says.

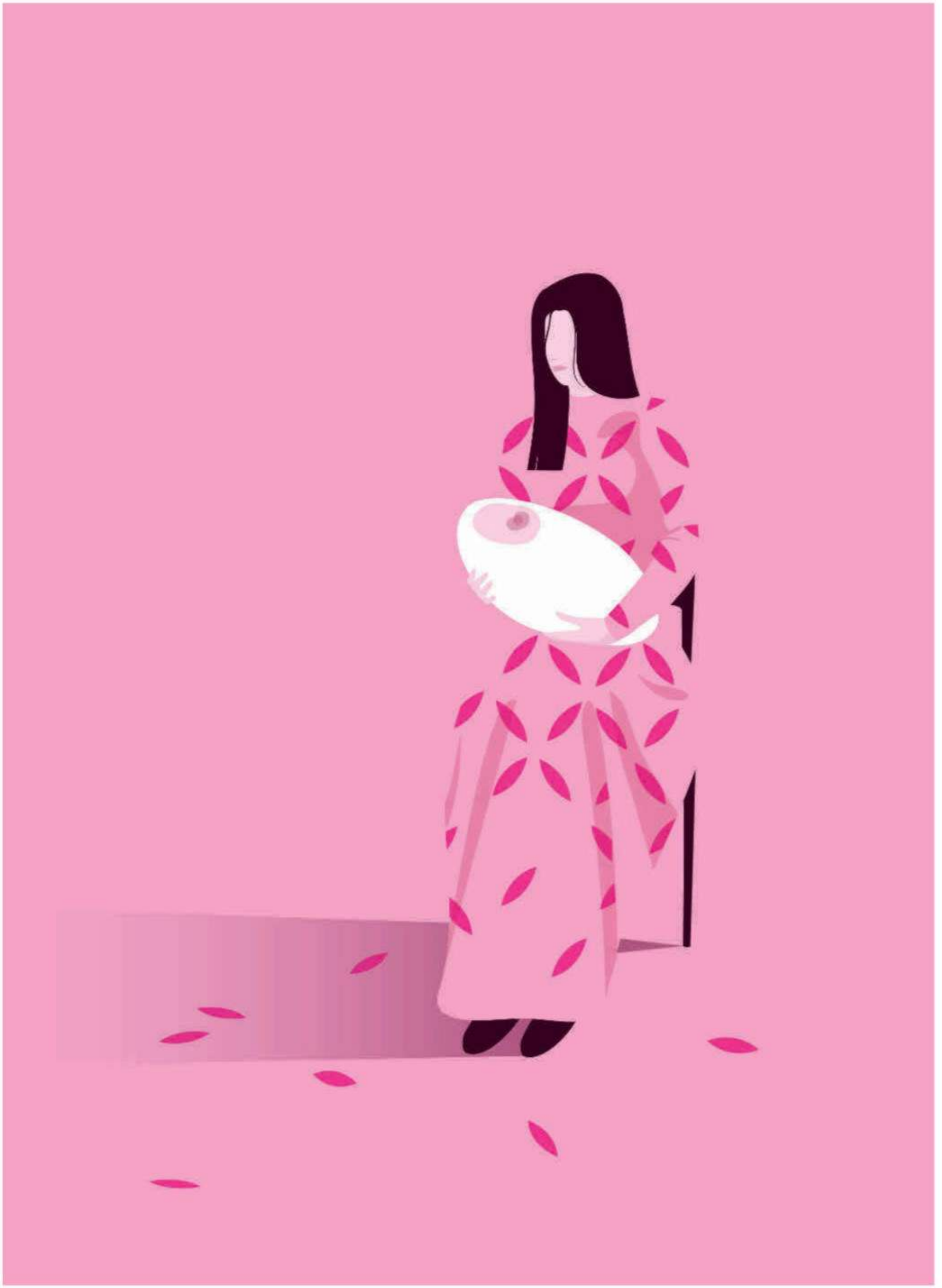
The effects of postnatal anxiety reach far beyond parental well-being. "It's tragic when it gets missed because people can suffer a great deal and it can interfere with the mother-infant bond," says Van Lieshout. This impaired emotional connection can affect a child's social and emotional development, especially in the first year of life. In extreme cases, it can result in rejection of the child. Postnatal anxiety can also affect how a mother perceives her bond with her child, further adding to her distress.

Insidious effects

All this goes to show that postnatal anxiety is an insidious condition, the causes of which will probably take some serious untangling. Thankfully, as awareness of it grows, we are starting to do just that. Most research to date has focused on women with postnatal depression, but given there is an overlap with anxiety – about 75 per cent of women who experience postnatal depression also experience anxiety – many believe the results can apply to both.

Some of the first studies of the causes of postnatal depression looked at pregnancy hormones. During pregnancy, the hormones oestrogen and progesterone rise to prepare the body for growing and delivering a baby. Within 48 hours of birth, however, they quickly decline. The assumption was that these changing levels were somehow responsible for postnatal depression.

To investigate, Miki Bloch, now at Tel Aviv University in Israel, and his colleagues ›



ELIA BARBIERI

artificially replicated these changing levels of progesterone and oestrogen in 16 women, half with a history of postnatal depression. For eight weeks, the volunteers were given the same increasing doses of the two hormones, before they were withdrawn without either the researcher or volunteer knowing. Of the eight women with a history of postnatal depression, five developed significant mood symptoms following hormone withdrawal. None of the other eight did.

"The best way to think about it is that every person who gives birth goes through this huge drop in oestrogen and progesterone after giving birth, but not every person develops postpartum depression or anxiety," says Lauren Osborne at Weill Cornell Medical College in New York. "So, it has to be something about people's vulnerability to the shift rather than about the level itself, because otherwise everybody would develop it."

Stress hormones

While researchers try to get a grip on what is behind this difference in vulnerability, other potential causes are being investigated. One of these is our stress response. The stress hormone cortisol also increases during pregnancy and has been linked with postnatal depression. However, most studies show no association between the absolute levels of cortisol and the condition, says Ilona Yim at the University of California, Irvine.

Instead, as with oestrogen and progesterone, it is thought that the body's reaction to the hormone is what affects the response. "The hormone in and of itself doesn't do anything," says Yim. "It needs to bind on a receptor somewhere in the body, and then that creates some change, or an organ reacts, or some other process starts happening." Essentially, two people with the same levels of hormones could experience different reactions, depending on the sensitivity of their receptors, she says.

"As a first-time mom, it was really hard to tell the difference between what's normal worry and what isn't"

Why these differences exist isn't yet known. That is partly because the funding hasn't always been available to do the lab studies needed, says Jamie Maguire at the Tufts University School of Medicine in Massachusetts. She is working with her team to tease out an answer in relation to stress. Their focus is on the role of the hypothalamic-pituitary-adrenal (HPA) axis, a physiological system that regulates how a person perceives stress and how their body reacts to that stress. During pregnancy, the stress-induced activation of the HPA axis is suppressed. "It's thought that this is a protective mechanism to prevent stress levels of hormones from adversely impacting the fetus," she says.

Maguire and her colleagues wondered whether this suppression could go awry in postnatal depression. They turned to mice to investigate the neurons in the hypothalamus that govern the activity of the HPA axis, specifically a protein called KCC2 that sits on the outside of neurons and helps move potassium and chloride ions in and out of the cells. They found that pregnant mice engineered to have no KCC2 protein in neurons that govern the activity of the HPA axis displayed depression-like symptoms and reduced maternal behaviours after giving birth.

"What we've been able to understand [in the lab] is that the inability to suppress the stress response during pregnancy increases vulnerability to mood disorders," says Maguire. "I think there's a combination of biological and environmental factors that can contribute."

As we learn more about the causes of depression and anxiety in general, researchers are looking at whether these can also apply postnatally. One growing area of research is the link between inflammation in the brain and generalised anxiety disorder, as well as the link between depression and the increased number of an immune cell called Th17, a helper T-cell that regulates inflammation. There is plenty of evidence that this link with helper T-cells is also seen in postnatal depression, but it is difficult to draw conclusions for anxiety, largely because much less research has been done.

That trend is starting to change. In 2022, Hao Ying at Tongji University in Shanghai, China, and colleagues assessed 226 women for signs of both conditions six weeks after giving birth while also testing their blood for helper T-cells and the signalling molecules they secrete, called cytokines. They found that levels of Th17 and one cytokine it secretes, called IL-17A, were positively linked with the risk of developing both conditions, and that levels of both were higher in women who had symptoms of postnatal anxiety than in those who didn't have symptoms.

We still don't know why these cells seem to have this effect, but IL-17A is known to have

DAVID SACKS/GETTY IMAGES

Up to 18 per cent of fathers develop anxiety after birth

SOLSTOCK/GETTY IMAGES

Exercise may help people with postnatal anxiety

a pro-inflammatory effect and cytokines can enter the brain. The team suggests that higher levels of Th17 cells and IL-17A could lead to inflammation in the brain, which may contribute to the development of postnatal anxiety.

While research into the biological causes of postnatal anxiety is still in its early days, we know more about why some people are at a higher risk of developing the condition. One factor is having had generalised anxiety disorder before, says Van Lieshout. "A significant proportion of people who develop some postpartum anxiety or pregnancy anxiety have had anxiety in their life." Bahri says she has had periods of anxiety in the past, but she had seen a therapist and wasn't feeling anxious when she became pregnant.

Sleep disruption

Situational changes can also make people vulnerable. Samantha Latorre at the University of Maryland says that medical complications, such as gestational diabetes, can increase someone's risk of developing postnatal anxiety. Van Lieshout says a history of pregnancy loss, an unplanned or unwanted pregnancy, a history of intimate partner violence or even major life changes like moving house can affect someone's vulnerability to the condition.

These "psychosocial" factors are thought to explain why adoptive parents and fathers can be affected. "There's been very little done biologically on fathers," says Osborne. "It's all about psychosocial factors and sleep disruption and some of the same psychosocial things that affect moms." The few studies that have been done look at testosterone levels, with one showing that lower levels of this hormone in fathers after the birth of a child are associated with depression.

Ultimately, postnatal anxiety is a function of biological, psychological and social factors, says Osborne. "I don't think we're ever going to get to the point where we say 'this is the one cause', but I think we will make substantial progress beyond where we are now in pinpointing those biological causes," she says. "But they're always going to interact with psychosocial causes."

When it comes to treatments, there is a much better idea of what works for postnatal anxiety. "We have very, very strong evidence that talk therapy, in particular cognitive behaviour therapy, is very effective," says Nichole Fairbrother at the University of British Columbia in Canada. She believes that publicly funding such therapy could make a huge difference to new parents. "There's a strong preference among perinatal people for talk therapy and, at present, that's really hard to access," she says.

Medications such as antidepressants can also be helpful, but Fairbrother says that many women are hesitant to take them. Often, this is due to fears that they will harm the baby, as these drugs are excreted in breast milk, although at levels that are generally considered safe. Hassanpour eventually started taking Zoloft (sertraline) for her anxiety, but she also sought out a therapist. "I personally think the therapy was a huge part of it. It just helped to normalise [the anxiety] and I was much – like 100 per cent – better," she says.

In addition to medication and therapy, physical activity can be helpful for those able to exercise. A study released last November showed that three or four aerobic exercise sessions a week, each lasting 35 to 45 minutes, could help in the prevention and treatment of postnatal depression, so it may also be helpful with postnatal anxiety. Cuddling your newborn is also thought to be beneficial, as it releases oxytocin, a hormone that has been shown to reduce anxiety in people with generalised social anxiety. And asking for – and accepting – assistance for everyday tasks may also help. Hassanpour says that she "struggled deeply to ask for help and felt I needed to do everything myself. That in and of itself affected many things as I was exhausted and overwhelmed."

Slowly, anxiety is making it onto the postnatal agenda. Last June, the American College of Obstetricians and Gynecologists released guidelines that recommend screening for both depression and anxiety during and after pregnancy. In the UK, the National Institute for Health and Care Excellence recommends that women be screened for generalised anxiety during their first appointment while pregnant and soon after giving birth.

Latorre is happy to see that postnatal anxiety is being talked about more frequently. Sadness and anxiety are normal emotions, just like happiness and joy, so it is important that we don't pathologise them, she warns. "But we don't want to miss them either when they become problematic."

"Nobody mentioned that postpartum anxiety can be a thing. I just think it's not as mentionable as postpartum depression because people think it's not as bad," says Bahri. "But it's not true. Anxiety can take over your life." ▮

Tina Knezevic is a writer based in Toronto, Canada

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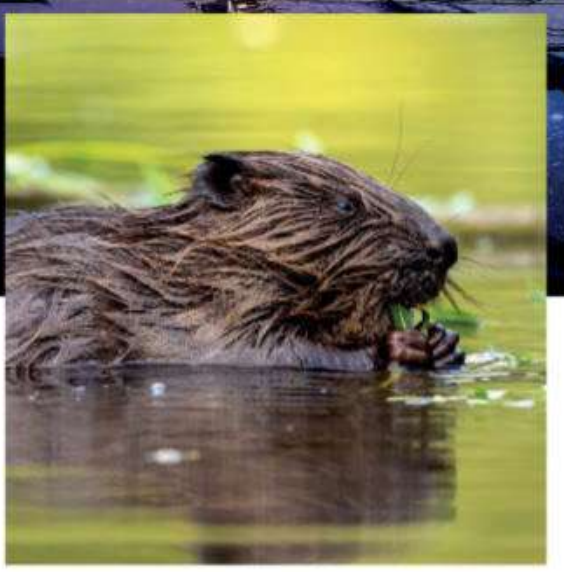

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Stargazing at home

Star dates for your diary

From a solar eclipse in April to a meteor shower in May, it's time to plan your astronomy calendar for the year, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

I HAVE been making notes about the stargazing spectacles I hope to see this year. Many depend on being in the right place at the right time, but there are lots of great things to look out for wherever you are. Here are a few of the most exciting cosmic events in 2024.

First up, meteor showers. These grace us every year, and the big hitters will be the usuals: the Lyrids in April, August's Perseids and December's Geminids. This year, the Eta Aquarids, which peak on 6 May, will coincide with almost no moonlight, making them one to watch out for too.

I am also looking forward to the dates when the planets line up with the stars or the moon to look particularly special. On 18 January, the half-lit moon will appear close to Jupiter in the night sky. There will be a lunar occultation of Venus on 7 April, visible in eastern parts of North America, where Venus will pass behind the moon. On 20 April, there will be a five-planet alignment, with Venus, Mercury, Neptune, Mars and Saturn all visible in a row just before sunrise. Then, on 18 December, there will be a lunar occultation of Mars, when Mars will pass behind the moon and then pop out again. This will only be visible from the north of the UK, and some parts of Canada, Greenland, Russia and Alaska.

On 8 April, a total solar eclipse will be visible from a 185-kilometre-wide strip across North America, stretching from Mexico to Canada and going through 13 US states. Elsewhere in North America, a partial eclipse will be visible. For those in the path of totality, the moon will block the sun for over 4 minutes, making it so dark that some stars and planets will be visible. Having seen my first total solar eclipse last year in Western Australia (pictured), I am looking forward to seeing this one in Texas.

STEFAN MALINOWSKI/ALAMY

We will then be graced with three supermoons in a row in September, October and November. These full moons will appear slightly bigger and brighter than usual. There will also be an annular solar eclipse on 2 October, which happens when there is a solar eclipse but the moon is too far from Earth to block out all of the sun, leaving a "ring of fire" around the moon as it passes in front of the sun. This will be visible from a small stretch of land across the southern tip of South America.

Whenever there are solar eclipses, there are lunar eclipses too. The lunar eclipse on 17 September, two weeks before the annular solar eclipse, will be a partial eclipse visible from Europe, most of Africa and most of North and South America.

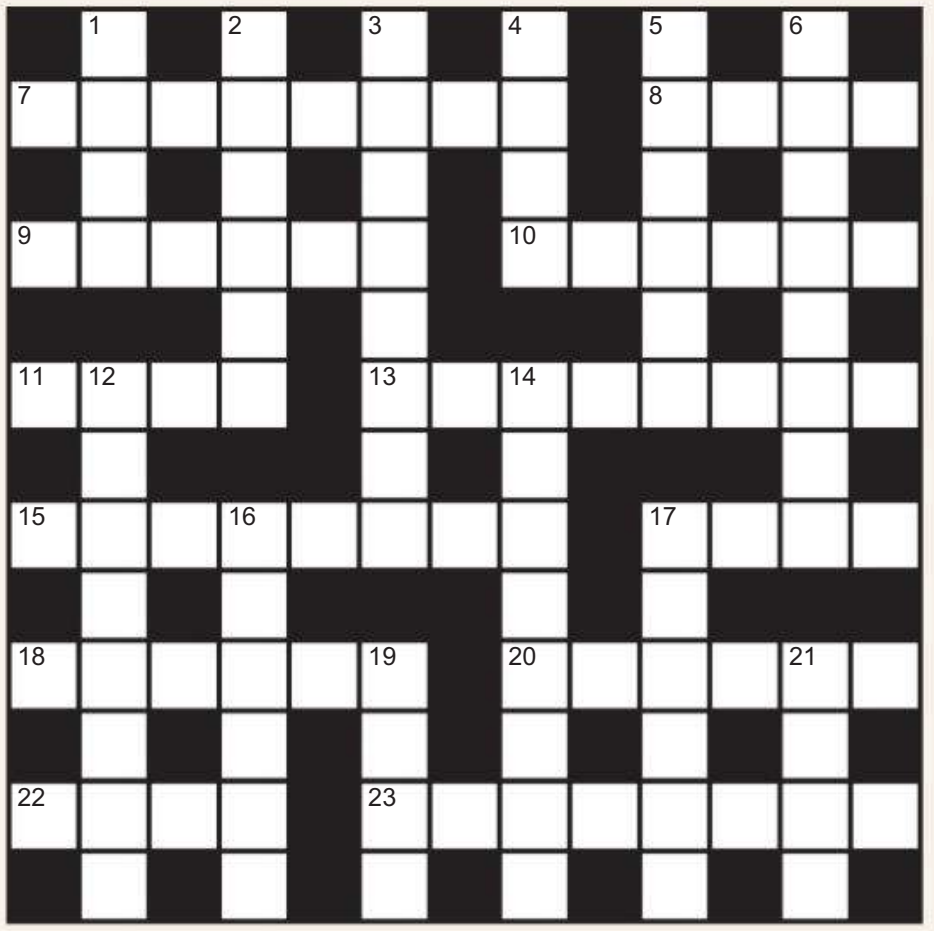
These are just a handful of standout dates for your diary. But I will be making time to go stargazing all year, watching the planets move and constellations change. As long as it isn't cloudy, any night spent looking at the stars is worth it. ▮

Stargazing at home appears every four weeks. Share your stargazing successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistStargazing

These articles are posted each week at newscientist.com/maker

Next week
Mathematics of life

Cryptic crossword #126 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Vitamin mixed in Thai meal (aluminium-free) (8)
8 Silent, tailless mongrel, safe at last (4)
9 No lead in buckles (6)
10 Like a baker's apron embellished with blossoms, say (6)
11 Fix hot tub by end of January (4)
13 Shook small wax structure, visibly angry (8)
15 Group from Scarborough site endures hard conditions (6,2)
17 Earn kiss... for starters ;-) (4)
18 Sail aimlessly around pair of Icelandic beaches, mostly? (6)
20 Seal coffin with bit of gum instead of acrylic, ultimately (6)
22 Axis label incorporated metal (4)
23 Human mimics both cats badly (8)

DOWN

1 Expression of surprise about hot curry ingredient (4)
2 Officially agree to cause rodent infestation? (6)
3 Initially, online jousting arena supports six players (8)
4 Insect's heading to the bottom bit of foliage (4)
5 Foist mischievous child on Wooster when every second counts (6)
6 Foot of client nibbled by doctor fish (8)
12 Oft-published academic takes lithium, one capsule at first (8)
14 Deconstructed triangle area calculation in calculus (8)
16 Galileo primarily illuminated church fault (6)
17 Green rhizome had been a 7 Across? (6)
19 Saucy parade lacks leader (4)
21 Fort surrounded by south-eastern climbing newts (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #233
set by Bethan Ackerley

1 How old was Louis Braille when he invented his eponymous writing system, 200 years ago this year?

2 Which substance is Charles Romley Alder Wright best known for synthesising, 150 years ago this year?

3 What was the name of the first operational nuclear-powered submarine, which entered service 70 years ago this month?

4 The AL 288-1 *Australopithecus* fossil, better known as "Lucy" or "Dinkinesh", was discovered in which country 50 years ago this year?

5 The Vera C. Rubin Observatory is tasked with carrying out which astronomical survey when it becomes fully operational later this year?

Answers on page 49

BrainTwister
set by Katie Steckles

#1 Digital sevens

Welcome to our new puzzle column!

Our devious BrainTwister enigmas will start with a first step, then add a twist (or two) to get you thinking about the problem differently.

61, 14234, 25, 1111111 and 95 are all numbers whose digits add to a multiple of 7.

What is the next number after 95 whose digits add to a multiple of 7?

Can you find a pair of consecutive numbers whose digits both add to multiples of 7?

What about a pair of numbers under 100 whose digits both add to multiples of 7, but that are two apart rather than consecutive?

Solution next week

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Lighting up

Which bicycle lights are safest and give the best visibility: pulsating, a fixed beam front and back light, or some other method, such as helmet or backpack lights?

Jon and Linda Reed
Ipswich, Suffolk, UK
As long-distance tandem cycle tourers, the best lights we have found are the disruptive style, where the pattern is irregular and the brightness very high, especially during the day when it is harder to catch the attention of a driver. This style of disruptive light pattern is usually only associated with bicycles, whereas a regular flashing or constant light could be numerous other things.

During daylight, our lights can be seen over a mile away – we have been told this by motorists more than once, but even so, we have still nearly been hit on a number of occasions. That is why mirrors, for us, are also essential, allowing us to "bail out" when we see vehicles aren't giving us enough clearance. They perhaps haven't spotted us, despite the lights.

"For tandem cyclists like us, mirrors are essential, allowing us to 'bail out' when vehicles aren't giving enough clearance"

Bryn Glover
Kirkby Malzeard, North Yorkshire, UK
May I respond from a motorist's point of view? I live in a rural community with narrow, often single-track roads with passing places. It would be physically impossible to give cyclists a 2-metre clearance either way. These roads are unlit and generally unmarked, and so, you may suppose, are more hazardous than wide, well-lit urban roads.

My experience is that an oncoming cyclist may have either steady or flashing lights, but in both cases, the beam will usually be directed at my windscreen, presumably to ensure that I see it. These lights, though relatively small, can be very intense and can cause road blindness and disorientation just as easily as a car at full beam can. Whenever I encounter one, I will invariably stop until the cyclist – and the serious hazard – has passed.

My preferred light of warning would be one that is large rather than intense, still or slowly flashing rather than the usual frenetic strobing, and not directly aimed at my eyes.

Mike Darke
Poole, Dorset, UK
I would caution against relying only on flashing red rear lights. They work well in good visibility (though they can be distracting), but in mist or fog I have found they can be very difficult for the approaching driver to see – especially if they are the bike's only rear light.

Andy Bebington
London, UK
I am both a cyclist and a driver. Having had several serious motor/bicycle collisions while riding (but none while driving), I think I have some input into the debate.

Firstly, flashing lights are vastly better than static ones. Static lights get lost at night among the myriad other lights I see from my driving seat; flashing ones spell "cyclist". These are especially valuable as rear lights, where the cyclist and driver are sharing the same side of the road (which are often narrow in the countryside).

Secondly, what are the front lights there for? Are they for conspicuity (again, flashing lights say "cyclist") or for illuminating the road (to enable the rider to see potholes and similar dangers)? The need for the latter is growing as local road authorities in the UK fail to maintain some roads to a safe standard, and can be needed even in town where street lights don't always reveal obstacles.

Thirdly, although not on the subject of lights, reflective ankle bands or panels on trouser legs, moving up and down regularly as the person pedals, also spell "cyclist" and draw the rider to the attention of motorists.

In a bike magazine some years ago, an impassioned question was posed by a rider: "Do I have to dress up like a Christmas tree to be safe?" My feeling is, if that is what it takes, then yes, I will do so. "I'm sorry, mate, I didn't see you!" won't cut it if it can be shown that the cyclist was doing their best to be visible (for example, me all lit up and dressed in orange versus a van in Croydon in November 1997).

Finally, and nothing to do with lights at night, why do so many cyclists dress in black? Do they not realise that they disappear into the shadows by day unless they also have a flashing light to let me, in my car, know they are there?

CLAUS LUNAU/SCIENCE PHOTO LIBRARY

If the moon hadn't formed from a planetary collision, would a bigger Earth still sustain life?

This week's new questions

Crash landing **If an object hadn't crashed into Earth to form the moon, as is hypothesised, Earth would be bigger. Would it still sustain life?** ***Chris Arnott****, Hitchin, Hertfordshire, UK*

Breaking in **Given the number of cars on the roads now, what are the chances of my remote key fob unlocking another car (and vice versa)?** ***Chris Humphries****, Keadby, Lincolnshire, UK*

Snap, crackle, pop

How can popped knuckles be so exceptionally loud?

Mark Thompson
Tewkesbury, Gloucestershire, UK
The loud noise produced when you crack your knuckles is due to the rapid formation of a gas-filled cavity within the synovial fluid that lubricates your joints.

When you pull or stretch your fingers, it lowers the pressure inside the joint, causing dissolved gases like carbon dioxide to form

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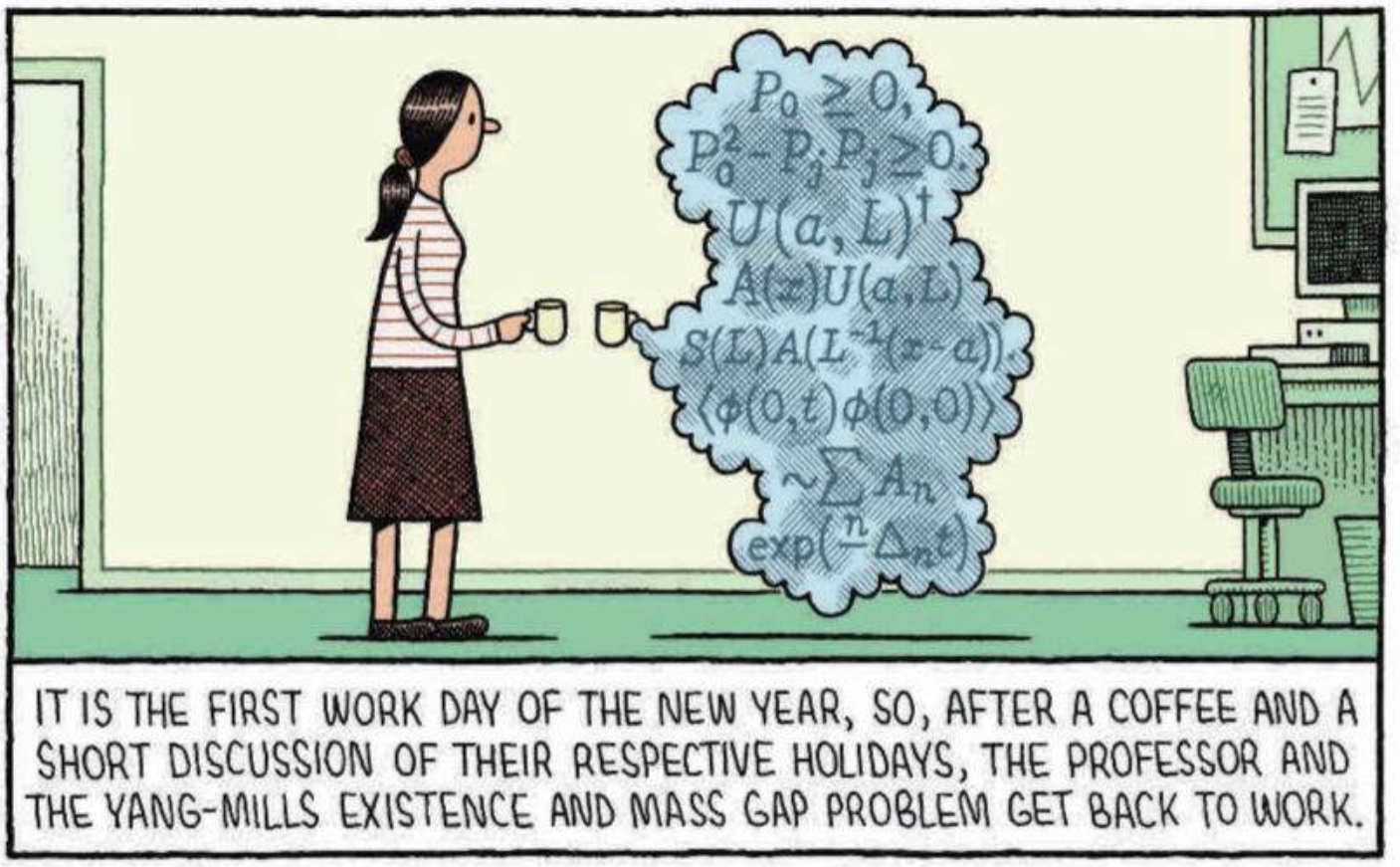
for New Scientist


$P_0 \geq 0,$
$P_0^2 - P_j P_j \geq 0,$
$U(a,L)^\dagger$
$A(x)U(a,L)$
$S(L)A(L^{-1}(x-a))$
$\langle\phi(0,t)\phi(0,0)\rangle$
$\sim \sum_n A_n$
$\exp(\frac{n}{-}\Delta_n t)$
IT IS THE FIRST WORK DAY OF THE NEW YEAR, SO, AFTER A COFFEE AND A SHORT DISCUSSION OF THEIR RESPECTIVE HOLIDAYS, THE PROFESSOR AND THE YANG-MILLS EXISTENCE AND MASS GAP PROBLEM GET BACK TO WORK.

bubbles. So cracking knuckles, with the sudden formation of these bubbles, creates a popping or cracking sound, similar to opening a bottle of pop, or soda.

However, excessive or forceful knuckle cracking may occasionally lead to minor swelling, ligament laxity or discomfort in surrounding tissues. If you keep doing this, it can lead to complications.

Pat French
Telford, Shropshire, UK
They aren't exceptionally loud.

The pop is caused by a bubble bursting in the finger joint as pressure is reduced when the joint is stretched. The sound of running water, from a domestic tap to a huge waterfall, is all brought about by bubbles. The pop also has a high frequency, meaning it is high pitched, which causes it to sound intense to the human ear.

The lesser water boatman, a 1.5-centimetre aquatic bug, can generate 99 decibels of sound. A shoal of tiny snapping shrimps can make enough noise to mask the sound of a ship. An individual shrimp can stun its prey with sound. The pop of a knuckle sounds loud, but it isn't exceptional.

"An individual snapping shrimp can stun its prey with sound, so the pop of a knuckle isn't exceptionally loud"

Squeezing out

What is the shortest space a parked car can get out of? Or a parking car can get into? (continued)

Grant Hutchison
Dundee, UK
Previous answers to this question have neglected the usefulness of entering a parking space while executing a handbrake turn, in which the driver uses the emergency brake to lock the car's rear wheels. This allows the car to be drifted into a space only a few centimetres longer than itself.

The current record is a space just 7.5 cm longer than a Fiat 500 driven by Alastair Moffatt in 2015.

Mark Inwood
Reigate, Surrey, UK
I have a lovely memory from the 1960s of parking my neon green Bond 875. As an earlier contributor noted, cars were lighter then. I arrived late for an appointment and, spotting an exactly Bond-sized gap, I reversed the back end into the space, jumped out and lifted the front end in to complete the manoeuver – only then noticing the applauding bus queue opposite! A quick bow, and I still made it just in time for my meeting.

David Clarke
Seaford, East Sussex, UK
No need to lift a car to get it into a small space. Get it bouncing on its suspension and it is easy to move sideways. You can fit a car into any space longer than its length. Many years ago, four of us easily moved a Ford Zephyr that had blocked us in a car park out of the way. ▮

Answers

Quick quiz #233 *Answers*

1 15
2 Heroin (also known as diamorphine or diacetylmorphine)
3 The USS Nautilus
4 Ethiopia
5 The Legacy Survey of Space and Time

Quick crossword #148 *Answers*

ACROSS 1 Educated guess, **8** Twin, **9** Anemometer, **10** Ninety, **11** Treetops, **12** Redevelop, **14** Hour, **15** Clot, **16** Magnesium, **20** Neomycin, **21** Neuron, **23** Fibre-optic, **24** UNIX, **25** The Black Death

DOWN 1 Ed White, **2** Ulnae, **3** Analyse, **4** Electromagnetic, **5** Geodes, **6** Electrons, **7** *Sleeper*, **13** E-commerce, **15** Chemist, **17** Non-acid, **18** Urolith, **19** School, **22** Uvula

#255 Final light bulb moment *Solution*

The lights will all be on after exactly 255 seconds.

The lights are behaving like 1s and 0s in binary. Starting at 00000000, they pass through each number, 00000001, 00000010, 00000011 and so on until reaching 11111111. This is the binary code for 255.

Yogurt in space

"Can Bulgarian yogurt enhance astronauts' performance during the Mars missions?" ask Izabela Shopova, Diana Bogueva, Maria Yotova and Svetla Danova in their study of that name published in the *Journal of Ethnic Foods*.

The researchers had seven people prepare and eat Bulgarian-style yogurt – made with *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*. The seven were, at that time, members of "a team of analog astronauts participating in a two-week analog mission in a closed, Mars-like environment at the Mars Desert Research Station in the Utah desert, the USA".

These stay-down-to-Earth astronauts were not, most of them, naive yogurt eaters. The study says: "Five out of the seven crew members confirmed having some sort of previous experience with yogurt."

The experiment extends a research tradition, Bulgarian yogurt having previously been consumed on the flight of the second Bulgarian astronaut in space, and also having been fed to sailors on a 150-day voyage to Antarctica, to 56 Bulgarian Air Force pilots and to a similar number of volunteers "in simulated shipwreck conditions".

The pre-Mars mission scientists report success: "With its long shelf life and probiotic properties, Bulgarian yogurt proves to be a valuable food item for colonizing the Red Planet." This, they say, "underscores the versatility of Bulgarian yogurt". They outline hopes that further research will produce insights about changes in gut microbiome diversity, as well as in "flatulence frequency".

In the names of science

Considered all together, the scientific names of living critters are a miscellany of hodgepodges. Richard Wakeford alerts Feedback to an attempt, published in the *Proceedings of the Royal Society B*, to savour the variety.

Twisteddoodles *for New Scientist*

Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

In their paper "Naming the menagerie: Creativity, culture and consequences in the formation of scientific names", Stephen B. Heard at the University of New Brunswick, and Julia J. Mlynarek at the Montreal Insectarium, both in Canada, sketch the manyness – and rue its difficulties.

Their appreciation goes to great lengths. They write: "Might species with names that are long and difficult to spell or pronounce find themselves understudied? One of us (SBH) has published repeatedly on the gallmaking moth *Gnorimoschema gallaesolidaginis* and hopes one day to type it correctly on the first try; the newly described myxobacterium *Myxococcus llanfairpwllgwyngyllgogerychwyrndrobwllllantysiliogogogochensis* offers a next-level challenge."

Sikkens, from the nose

Healthcare workers (HCW), consider yourself warned. "Nose picking among HCW is associated with an increased risk of contracting a SARS-CoV-2 infection," says a study called "Why not to pick your nose: Association between nose picking and SARS-CoV-2 incidence, a cohort study in hospital health care workers" in the journal *PLoS One*. It was written by Jonne J. Sikkens and five colleagues at Vrije University Amsterdam in the Netherlands. (Sikkens, Feedback notes, is obviously another name in the long annals of nominative determinism.)

Healthcare workers, please also consider, if only a little, the emotional side of nose picking.

Chittaranjan Andrade and B. S. Srihari at the National Institute of Mental Health and Neurosciences in Bengaluru, India, were awarded the 2001 Ig Nobel public health prize for their discovery that nose picking is a common – and emotionally healthy – activity among teens. They documented their gleanings in a paper called "A preliminary survey of rhinotillexomania in an adolescent sample", published in the *Journal of Clinical Psychiatry*.

Thus the covid-19 pandemic has added risk and worry to yet another small, otherwise-comforting (bar the disgust aspect) bit of daily life.

Penetrating question

Can light penetrate through pomelos and carry information?

The question is addressed in a study called "Can light penetrate through pomelos and carry information for the non-destructive prediction of soluble solid content using Vis-NIRS?" Hao Tian and colleagues at Zhejiang University, China, published it in the journal *Biosystems Engineering*.

Pomelos are ancestors of grapefruits. The latter is thought to be the love child of a long-ago romance between a pomelo and an orange. "Vis-NIRS" is a sibilant abbreviation for the phrase "visible near-infrared spectroscopy". "Soluble solid content" is the English-language phrase that some people mean when they use the slangy utterance "SSC".

The study concludes that yes, "light can penetrate through pomelos and carry information for the non-destructive prediction of SSC using Vis-NIRS".

This accords with grapefruit family tradition. Word arrived in 2017, in a study by Khayelihle Ncama at the University of KwaZulu-Natal, South Africa, and his colleagues, that light can penetrate through both grapefruits and oranges and can carry information. Deliciously useful information: "[Our] results demonstrated the ability of Vis/NIRS to non-destructively predict sweetness and flavour attributes of oranges and grapefruit." ▮

Marc Abrahams

Events

NewScientist

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MARINE BIOLOGY AND CRUISES

Whale watching and marine ecosystems in the Azorean Islands: Portugal

7 May 2024 | 7 days

A rare opportunity to actively take part in whale research and get an opportunity to watch the social interactions of whales. Spend your days exploring, and learning about marine life, current conservation efforts, intelligence and ecosystems of the hidden paradise of the richly biodiverse Azores islands.

Darwin's Galapagos: Ecuador cruise

26 August 2024 | 8 days

Considered as one of the world's greatest wildlife destinations, cruise the Galapagos Islands as Charles Darwin did, onboard an exclusive yacht. Discover sea lions, marine iguanas, blue footed boobies and giant tortoises, accompanied by conservationists as you explore this awe-inspiring volcanic archipelago.

Ecology expedition through the Amazon and Pantanal: Brazil

26 September 2024 | 13 days

Travel onboard the traditional motor yacht Tucano to voyage through one of the most diverse ecosystems in the world, the Brazilian Amazon. Leave the main tourist path behind and glide through the small tributaries woven between the rainforest in search of howler monkeys, spider monkeys and tamarins.

The science of Antarctica, South Georgia and Falklands expedition cruise

19 November 2024 | 21 days

A true expedition to the most remote continent on this planet, Antarctica. Discover historic Stanley in the Falklands, stand in awe before the world's largest king penguin colonies in South Georgia and experience the grandeur of gigantic icebergs as you navigate ice-choked channels in Antarctica.

In the wake of Alfred Wallace: Indonesia cruise

22 January 2025 | 13 days

Follow in the footsteps of one of the greatest naturalists of all time, Alfred Russel Wallace, aboard a stunning luxury sailing ship. Explore Indonesia's Spice Islands and Raja Ampat Islands as Wallace did, marvelling at their biodiversity and stunning beauty.

The science of glaciers and whales: Alaska's Inside Passage

31 July 2025 | 9 days

Experience calving glaciers, wildlife-filled fjords, stunning National Parks and endless tundras. The historic route traversing the spectacular Inside Passage is particularly special. The abundant wildlife in the region includes sea lions, sea otters, porpoises, orcas and humpback whales.

Find out more

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NATURAL WORLD

Rewilding in the Côa valley: Portugal

29 April 2024 | 6 days

Journey through Portugal's wild landscapes of the Côa valley and Fain a deeper understanding of the vital work being carried out by Rewilding Portugal. Learn how, through rewilding, wildlife's natural rhythms are creating wilder, more biodiverse habitats that encourage nature to flourish.

In the footsteps of Alexander von Humboldt: Ecuador

16 August 2024 | 11 days

Follow in the footsteps of ecologist, Alexander von Humboldt, and explore Ecuador's stunning natural wonders, including the Avenue of the Volcanoes, Amazon and Cloud Forest. In addition, discover Ecuador's colonial architecture, colourful markets and fascinating cultural history.

Rewilding in the Central Apennines: Italy

23 September 2024 | 6 days

Journey into Italy's Central Apennines region and discover a fascinating introduction into the concept and practicalities of rewilding. Spend time tracking wildlife on foot in the company of a specialist nature guide, while learning more about the Rewilding Italy project.

Churchill polar bear expedition: Canada

19 October 2024 | 7 days

Travel to Churchill in northern Canada to visit the world's greatest concentration of polar bears. Accompanied by experts who will take a deep dive into the life and natural history of the polar bear, and learn about the role of protected areas and ecotourism in the protection of polar bears and arctic biodiversity.

The science of biodiversity: Costa Rica

6 November 2024 | 13 days

This trip encompasses a wealth of fascinating ecosystems, including cloud forests, wetlands, primary rainforests, volcanic zones and the rich variety of life in marine reserves and national parks. Local guides, conservationists, biologists and naturalists will create a fully immersive experience into the country's natural splendours.

Carnivore conservation insight: Zambia

14 November 2024 | 8 days

An up-close and behind-the-scenes look at large carnivore conservation in South Luangwa National Park, Zambia. Enjoy game drives, boat and walking safaris, with opportunities to see wildlife including elephants, lions, hyenas and African wild dogs, as well as many other species.

Find out more

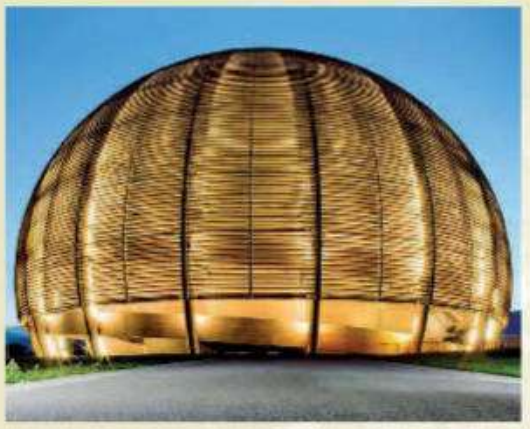
newscientist.com/tours/nature

ASTRONOMY AND PHYSICS

The science of whisky: Scotland Cruise

29 September 2024 | 8 days

A whisky lover's dream cruise, taking you deep into the science of how whisky is made and how different processes and stimuli affect its flavours, while touring renowned Scottish distilleries on the islands of Islay and Jura.



CERN and Mont Blanc; Dark and frozen matter: Switzerland and France

5 May 2024 | 6 days
8 October 2024 | 6 days

Prepare to have your mind blown by Europe's particle physics centre CERN, where researchers operate the famous Large Hadron Collider, nestled near the charming lakeside town of Geneva. In addition, explore Mont Blanc and the nearby glacier.

Astronomy and volcanoes in the Canary Islands: Spain

10 December 2024 | 7 days

Visit an array of telescopes and take part in expert-led stargazing at multiple sites across the islands of Tenerife and La Palma. UNESCO recognized La Palma as a designated Biosphere Reserve for its volcanic landscape.

Freud's Vienna: Psychoanalysis and the Viennese schools: Austria

25 November 2024 | 5 days

Gain insight into the mind of Sigmund Freud and the city in which he spent most of his life. Uncover how he explored the subconscious and became known as the founder of psychoanalysis. Learn about other key Austrian psychological thinkers, including Alfred Adler and Viktor Frankl.

Renaissance astronomy in Kepler's Prague: Czech Republic

15 September 2024 | 6 days

Discover the legacy of the Renaissance period astronomers Johannes Kepler and Tycho Brahe in Prague, the city of a hundred spires, where astronomy, maths, music and art connect. Journey to the heart of early science, exploring Prague's medieval marvels and walking the streets as Kepler and Brahe did.

Chile: The world capital of astronomy

March 2025 | 12 days

With unique geographical and climate conditions and 70 per cent of the world's telescopes, Chile truly is the world capital of astronomy. Gain hands-on experience at historical and modern observatories, meet local experts and stargaze at several sites near San Pedro, Santiago and Vicuña.

Find out more

newscientist.com/tours

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Discovery Tours

SCIENCE HISTORY AND INNOVATION

The birthplace of modern medicine: France

10 June 2024 | 7 days

From Louis Pasteur to Marie Curie, discover the foundations of the modern science of medicine in two French cities: Paris, where the 'Paris School' of hygiene and hospital teaching flourished and Montpellier, home to the world's oldest university medical faculty.

Bohr's Copenhagen: Physics past and future: Denmark

3 July 2024 | 6 days

Visit the institutes and sites where Niels Bohr formulated his theories, uncovering a rich history of scientific developments not only by Bohr himself, but by a host of Danish scientists, including Tycho Brahe and Ole Rømer.

The science of the waterways: England and Wales

July 2024 | 7 days

Explore the science of the waterways of England and Wales while visiting six of the seven British wonders of the waterways, including Pontcysyllte Aqueduct, Standedge Tunnel and Bingley Five Rise Locks. Marvel at the engineering work and learn about the history of this 200-year-old network of canals.

Science history of Scotland

5 September 2024 | 5 days

Discover Edinburgh and Glasgow's most famous scientific thinkers. With expert talks and the opportunity to explore sites from the Scottish Enlightenment, a period of incredible scientific and intellectual creativity in the 18th and early 19th centuries.

Science of the Incas: Peru

17 September 2024 | 10 Days

Experience a full immersion into the Inca civilisation's most important archaeological sites, including Machu Picchu. Get to the heart of how Hiram Bingham "discovered" Machu Picchu while exploring the science and history of the beautiful Sacred Valley.

Nobel's Stockholm: Celebrating science through space and time: Sweden

21 September 2024 | 6 days

Explore the beauty of Stockholm, a haven of scientific thought that was home to Alfred Nobel, Carl Linnaeus, Jons Jacob Berzelius and more. Examine the scientific heritage of the city past and present, and learn about the Noble prizes, which were created to celebrate great achievements in science.

Find out more

newscientist.com/tours/history

GEOLOGY AND EARTH SCIENCE

Retracing Charles Darwin's travels across North Wales

13 May 2024 | 6 days

Uncover the geology of the dramatic Eryri (Snowdonia) National Park and see how it has been transformed by volcanic and glacial activity over the years. Walk in the footsteps of famous scientist and geologist Charles Darwin and discover sites from his childhood.

The Rockies and the Badlands: Geology and dinosaurs in Canada

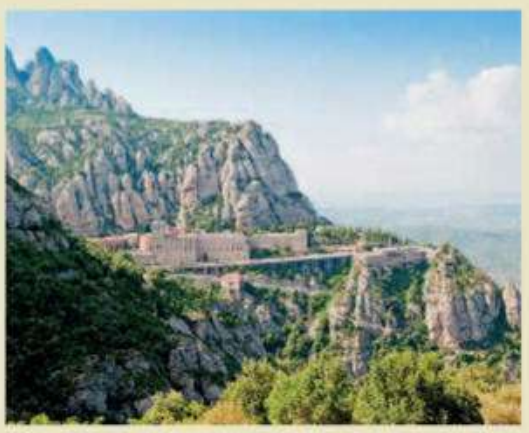
17 June 2024 | 7 days

Tour the majestic Rocky Mountains west of Calgary and the otherworldly Badlands. Traverse the stunning scenery and geology of southern Alberta. Visit two World Heritage Sites with world-class rock outcrops and outstanding dinosaur fossils.

Geology, conservation and culture: Vietnam

17 August 2024 | 13 days

Discover a different side to Vietnam in this wide-ranging tour that explores the country's geology, landscapes, animal conservation and history. Experience tropical jungles, limestone caves, blissful villages and amazing feats of underground engineering.



The geology of the Pyrenees: Spain

15 September 2024 | 7 days

Explore the mountain landscapes, geology, culture, food and wine of two of Aragón, one of Spain's distinct and unique autonomous regions. Uncover the amazing processes behind the formation of mountain belts as you're immersed in the spectacular scenery and geological structures of the central Pyrenees.

A desert adventure: Landscapes and cultures of Utah, USA

25 September 2024 | 7 days

Explore the landscapes and cultures of South-east Utah which holds a wealth of fascinating geological and cultural stories. Visit famous locations such as Monument Valley, as well as lesser-known historical sites, such as Newspaper Rock and ghost towns of the old west.

Land of fire and ice: Iceland

25 October 2024 | 8 days

Join an unforgettable tour of Iceland's majestic landscapes. Discover the awe-inspiring might of the planet and marvel at the sights, sounds and smells of erupting geysers, hot springs and bubbling fumaroles. Get up close to stunning glaciers, waterfalls and tectonic plates pulling apart.

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ARCHAEOLOGY AND PALAEONTOLOGY

Ancient caves, human origins: Northern Spain

2 June 2024 | 7 days
26 August 2024 | 7 days

Travel back 40,000 years and discover some of the world's oldest known cave paintings. Experience the wonders of several renowned caves full of art from before the dawn of civilisation, including El Castillo, Las Monedas, La Peña Cave, El Pindal and Tito Bustillo.

Neanderthal origins: Southern France

8 June 2024 | 10 days
21 September 2024 | 10 days

Step back in time on a journey to the key Neanderthal and Upper Palaeolithic sites of southern France between Bordeaux and Nice. See some of the oldest cave paintings, skeletons, stone tools, and artifacts left by archaic humans.

Pre-historic origins: Southwest England

15 July 2024 | 5 days

Immerse yourself in the early human periods of the Neolithic, Bronze and Iron ages on this gentle walking tour through southern England. Visit several UNESCO, National Trust, and English Heritage sites, including Stonehenge and Avebury Circle.

Dinosaur hunting in the Gobi Desert: Mongolia

27 August 2024 | 15 days

A thrilling and unique expedition to find dinosaur remains in the beautiful wilderness of the Gobi Desert. Participate in live fossil digging across key sites, and potentially be the first person in 80 million years to set eyes on your discovery.

Human origins - Neolithic and Bronze age: Turkey

12 September 2024 | 11 days

Discover the dawn of civilisation where our Neolithic and Bronze age ancestors changed from hunter-gatherers to organised societies with agriculture, ritual, and an understanding of the wider world.

Temples, fortifications and archaeology: Megalithic Malta

11 November 2024 | 6 days

Explore the islands of Malta and Gozo, both rich in remarkable history and archaeological sites. Visit prehistoric temples that are thought to be the earliest accessible free-standing buildings in the world, as well as medieval settlements and the walled city of Mdina.

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